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Rabi Maize and its Yielding Ability

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Abstract

Maize, the "queen of cereals," has found a new throne in India's winter fields. *rabi* maize, which was traditionally a *kharif* crop, has becoming more common because of its excellent growing conditions, which increase yields and economic benefits. These favorable conditions, includes mild temperatures and reduced pest pressure. This allows for better water management, enhanced nutrient uptake, and improved plant stand establishment. With yields often surpassing those of *kharif* maize, *rabi* maize offers not only economic benefits but also plays a crucial role in agricultural diversification and sustainability. Despite challenges like climate change and market volatility, *rabi* maize holds immense potential for boosting agricultural productivity and farmer incomes. This winter crop is not just a testament to agricultural innovation but a crucial step towards ensuring food security and sustainable farming practices in India.

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1. Introduction

Maize, often referred to as the "queen of cereals," is cultivated throughout the year due to its photo-thermo-insensitive nature and its high genetic yield potential compared to other cereals. While maize is primarily a *kharif* season crop, *rabi* maize has gained significant importance in India's overall maize production in recent years. Grown from October to April, *rabi* maize plays a crucial role in providing high yields, economic benefits, and contributing to crop diversification (Ayalew and Sekar, 2016). The ideal growing conditions during the *rabi* season such as mild temperatures, reduced pest and disease pressure, and improved water management enable *rabi* maize to yield better than *kharif* maize. Maize is grown on 185.12 million hectares of land worldwide, yielding 872.06 million tonnes and 4.9 t ha^{-1} of productivity. The total area under cultivation for maize in India is 8.49 million hectares, yielding 21.28 million tonnes and a productivity of 2.5 t ha^{-1}. 1.2 million hectares of *rabi* maize are produced annually, yielding 5.08 million tonnes with an average productivity of 4.00 t ha^{-1}. (Reddy et al., 2018). Bihar has been awarded with Krishi Karman Award for highest maize production in the country during 2016-17.

The introduction of US double-cross maize hybrids in Bihar during

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the mid-1960s unexpectedly thrived in the winter (*Rabi*) season after failing in the monsoon (*Kharif*) season. Initial trials revealed significantly higher yields and free from pests and diseases during *rabi*. This prompted extensive multi-location trials to optimize hybrid performance through tailored agronomic practices. Consequently, winter maize cultivation expanded beyond Bihar, reaching Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra, Uttar Pradesh, Madhya Pradesh, West Bengal, Odisha, and Gujarat (Yadav et al., 2014). The shift to *rabi* cultivation showcased the importance of adapting crop strategies to specific regional climate conditions. This adaptation highlighted the significance of matching crops to regional climates, driving agricultural growth. The Indo-Gangetic Plains, with their cool, dry winters and fertile soils, provide ideal *rabi* maize conditions, supported by reliable irrigation and reduced pest attack. Similarly, *rabi* maize is increasingly cultivated in Peninsular India, including Andhra Pradesh, Karnataka, and Tamil Nadu, as well as the northeastern plains. Maize's versatility, serving as grain, feed, fodder, and various specialty foods like sweet corn and popcorn, alongside its industrial applications as mentioned in fig (1), establishes it as a globally significant commodity, fueling international agriculture.

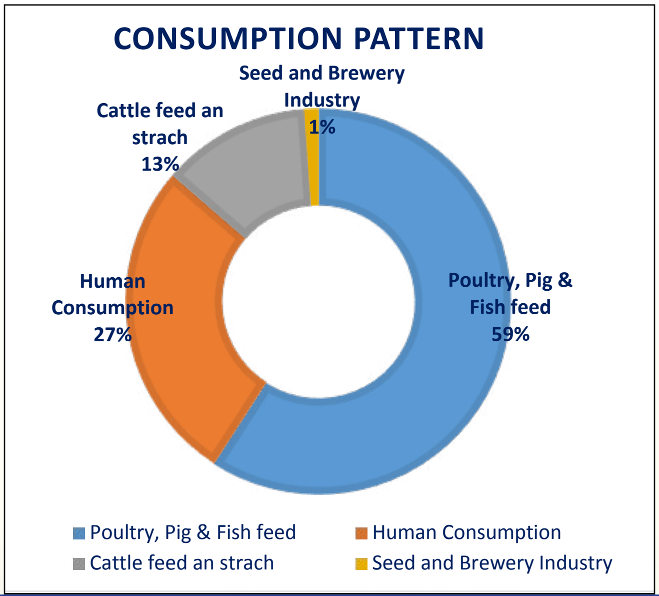

Figure 1: Consumption pattern of maize; (Yadav et al., 2014)

2. Origin of *Rabi* Maize

In 1961, *rabi* maize emerged in Bihar after US hybrids faltered in the *kharif* season. The Dholi Pusa Centre, now Dr. Rajendra Prasad Central Agricultural University, became the origin of this cultivation in India, leveraging Bihar's ideal winter climate and fertile soils. Research at Dholi Pusa, particularly under Dr. Rameshwaram Singh, developed high-yielding varieties and improved practices, solidifying Bihar's pioneering role. Through his dedicated work, he significantly elevated Bihar's standing as a leading maize-producing state, not only boosting overall yields but also fostering sustainable agricultural practices. He spearheaded the innovative technologies that optimized resource utilization and maximized crop output. These advancements solidified maize's position as a vital *rabi* crop in the region, ensuring its continued success and contributing to the agricultural prosperity of Bihar.

3. Reasons for High Yields in *Rabi*

i. Better water management

• In the *rabi* season, the crop avoids issues like waterlogging, fertilizer leaching, and damage from pre-flowering stalk rots, as there is no regular precipitation.

• One of the key advantages is the ability to carry out essential field operations at the optimal time.

• Higher yields are achieved when fertilizer leaching is prevented, maximizing nutrient usage

• Depending on their growth stage, heavier soils need adjustments, while light soils require watering at 70% moisture availability.

ii. Mild and favorable temperature:

• *Rabi* maize plants are more efficient due to reduced photorespiration losses, which result from lower night temperatures and a larger effective photosynthetic leaf surface.

• During *rabi*, there are seven to nine hours of sunshine, compared to three to five hours during the *kharif* crop season.

• Maximizing light interception during longer sunshine hours, which optimizes photosynthetic output, especially in high-density plantings

• Canopy modeling confirms optimized light distribution and photosynthetic output, especially advantageous for high-density planting.

• Reduced photorespiration allows for greater resource allocation towards growth and grain filling, leading to improved nitrogen use efficiency (Nirupma et al., 2015).

iii. Better response to macronutrients:

• *Rabi* maize has the potential to deliver higher yields and superior crop quality compared to the *kharif* season, as it responds more effectively to nitrogen and other macronutrients.

• Effective soil and water management practices can significantly reduce losses during the *rabi* season.

• The improved efficiency of fertilizers, a major contributor to cultivation costs, allows for a reduction in production expenses during this season.

iv. Management of diseases and insect pest

• The level of infection or infestation and the extent of damage due to various diseases and insect pests are lower in *rabi* than in *kharif*

• Lower humidity reduces the incidence of diseases and pests, leading to healthier plants and higher yields.

• Stress-tolerant hybrids and stable irrigation enhance plant resistance, leading to suppressed pest populations, reduced disease spread, and improved yield stability.

v. Establishment of better plant stand

• *Rabi* maize benefits from enhanced plant stand establishment due to favorable soil and water management practices, coupled with reduced pest and disease pressure.

• Proper irrigation, tailored to specific soil types, minimizes water loss and boosts productivity.

• Enhanced irrigation, including fertigation, ensures optimal soil moisture and nutrient delivery for uniform germination and robust development

• Effective soil management, precise irrigation, and natural pest suppression collectively contribute to successful crop establishment.

• Transplanting maize in winter ensures a better crop stand by reducing bird damage and uneven seedling emergence. It leads to higher plant densities, uniform crops, and enhanced overall productivity.

vi. Better weed management

• In *rabi* due to effective water management and low temperature, weeds can be controlled effectively.

• *Rabi* conditions such as lower temperatures and effective water management naturally suppress weed growth and also inhibit warm-season weed germination, reducing weed pressure.

• The *rabi* season offers the opportunity to execute field operations at optimal times, ensuring better plant stands and weed management.

• Controlled irrigation practices in *rabi* allow precise water application, minimizing the moist conditions that favor weed proliferation (Nagasai and Velayutham, 2018).

vii. Economic benefits

• *Rabi* maize contributes significantly to the national maize production, with states like Bihar experiencing high productivity levels that surpass the national average.

• High-yielding hybrids respond well to macronutrients, improving yield potential and reducing production costs.

• Better disease management lead to increased profitability for farmers, making *rabi* maize a more attractive option.

• The increasing demand for maize in animal feed, food, and industrial sectors creates opportunities for expanding *rabi* maize cultivation across the Indo-Gangetic plains (IGP).

• Promoting *rabi* maize can reduce reliance on traditional crops like rice and wheat, improve soil health, and boost farmers' income.

4. Prospects of Winter Maize

Winter maize has a lot of potential because of its versatility and strong demand. Because it is less susceptible to pests and diseases than summer maize, it yields more. It is a reliable crop for farmers since it may reduce the chance of unpredictable rainfall during monsoon seasons. Its productivity and resilience are further increased by the creation of hybrid seeds and better agronomic techniques, fostering both economic growth and food security. (Govind et al., 2015).

5. Challenges of Winter Maize

Despite its potential, winter maize faces several challenges. Climate change, with rising temperatures and erratic weather, poses a significant threat to yields. Farmers remain dependent on hybrid seeds from international corporations, making them vulnerable to supply chain disruptions. Limited water availability and shrinking agricultural land further constrain expansion. Infrastructure deficits hinder export potential in some regions, while intensive farming practices contribute to soil degradation, affecting long-term sustainability. Additionally, fluctuating maize prices create uncertainty for farmers, impacting profitability and investment decisions. Bridging yield gaps in less favorable environments through genetic improvements and better crop management is essential to sustaining growth and meeting rising demand. Regulatory support, resilient agricultural systems, and targeted research are crucial for overcoming these challenges. (Govind et al., 2015).

6. Conclusion

Rabi maize has emerged as a cornerstone of India's agriculture, showcasing the power of adapting crop strategies to regional climates. Its journey from a failed *kharif* experiment in Bihar to a vital winter crop across the nation highlights the importance of research, innovation, and understanding local agro-climatic conditions. The potential for growth and resilience makes it an attractive option for farmers seeking reliable and profitable crops. While challenges like climate change and market volatility persist, the prospects for winter maize remain bright. Continued investment in genetic improvements, sustainable farming practices, and robust infrastructure will be crucial in unlocking its full potential. By embracing innovative agronomic practices and hybrid technologies, India can further capitalize on *rabi* maize's potential, ensuring both economic prosperity and food security for years to come.

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