Agri Articles
(e-Magazine for Agricultural Articles)
Volume: 06, Issue: 03 (MAY-JUNE, 2026)
Available online at http://www.agriarticles.com

Comparative Performance of Kharif and Spring Maize: Implications for Productivity and Resource Use Efficiency

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Maize (*Zea mays* L.) is the third most important cereal crop in India after rice and wheat and serves as a major source of food, feed and industrial raw material. The crop is cultivated throughout the year under varying agro-climatic conditions. Among the different growing seasons, kharif and spring maize occupy a prominent place in Indian agriculture. Kharif maize is grown during the southwest monsoon season, while spring maize is cultivated under irrigated conditions during the winter–spring period. The productivity of maize is strongly influenced by climatic factors such as temperature, rainfall, solar radiation and relative humidity. Seasonal variation affects crop phenology, biomass accumulation, nutrient uptake and grain filling. Consequently, substantial differences in growth and yield have been reported between kharif and spring maize. Understanding these differences is important for developing efficient production strategies and maximizing farm profitability.

Growth Performance

The growth and development of maize depend largely on environmental conditions prevailing during the crop growth period. Spring maize generally experiences moderate temperatures during vegetative growth and bright sunshine during reproductive stages. These conditions promote higher photosynthetic activity, increased leaf area development and greater dry matter accumulation. In contrast, kharif maize is exposed to frequent rainfall, cloudy weather and high humidity. Although adequate soil moisture is available, reduced solar radiation may limit photosynthetic efficiency. Excessive rainfall may also cause temporary waterlogging, adversely affecting root growth and nutrient uptake. Consequently, spring maize often records greater plant height, leaf area index and biomass production than kharif maize.

Yield Attributes and Grain Yield

Yield differences between kharif and spring maize are primarily attributed to environmental conditions during flowering and grain filling. Spring maize generally produces longer cobs, more grains per cob and higher test weight because of favorable temperature and radiation regimes. Several studies have reported significantly higher grain yields in spring maize compared with kharif maize. Grain yields of spring maize commonly range from 7–10 t ha^{-1} under irrigated conditions, whereas kharif maize yields generally vary between 4–7 t ha^{-1} depending on rainfall distribution and management practices. Better pollination, reduced disease incidence and longer grain-filling duration contribute to enhanced productivity in spring maize.

Water and Nutrient Use Efficiency

Kharif maize largely depends on monsoon rainfall and therefore requires fewer irrigations. This reduces production costs and makes the crop suitable for rainfed areas. However, irregular rainfall patterns may cause moisture stress during critical growth stages. Spring maize requires assured irrigation throughout the growing period but often exhibits higher water-use efficiency because of greater grain production per unit of water consumed. Nutrient-use efficiency is also generally higher in spring maize due to reduced nutrient losses through runoff and leaching. Efficient irrigation and nutrient management practices further enhance productivity during the spring season.

Pest and Disease Incidence

Warm and humid weather during the kharif season favors the development of insect pests and diseases. Stem borers, leaf blights and downy mildew are commonly observed in kharif maize. Increased weed infestation also contributes to yield losses. Spring maize is usually subjected to lower pest and disease pressure because of relatively dry atmospheric conditions. Reduced biotic stress improves crop health and allows greater allocation of assimilates toward grain production.

Economic Analysis

Economic evaluations consistently indicate higher profitability of spring maize under irrigated conditions. Although cultivation costs are higher due to irrigation expenses, the substantial increase in grain yield results in greater net returns and benefit–cost ratio. Kharif maize remains economically viable in rainfed regions where irrigation resources are limited. The profitability of both seasons can be enhanced through the adoption of high-yielding hybrids, balanced nutrient management and integrated pest management practices.

Climate Change Implications

Climate change is expected to influence maize production through rising temperatures and increased variability in rainfall. Kharif maize is particularly vulnerable to extreme rainfall events, flooding and prolonged dry spells. Spring maize, while less dependent on rainfall, may face heat stress during reproductive stages if temperatures continue to rise. Climate-smart technologies, conservation agriculture practices and stress-tolerant hybrids will play a crucial role in sustaining maize productivity across seasons. Appropriate sowing dates and improved water management strategies can further reduce climate-related risks.

Conclusion

Comparative analysis of kharif and spring maize indicates that spring maize possesses greater yield potential, higher water-use efficiency and superior economic returns under irrigated conditions. Favorable climatic conditions during crop growth and grain filling contribute significantly to its enhanced productivity. Kharif maize, however, remains an important component of rainfed farming systems because it effectively utilizes monsoon rainfall and requires lower irrigation inputs. Selection of the appropriate maize-growing season should be based on resource availability, climatic conditions and production objectives. Adoption of improved crop management practices can help maximize productivity and profitability in both seasons.

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