

Optimizing winter maize production in Bihar:

Addressing the yield gaps through practical insights, strategies, and evidenced yield improvements

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Winter maize has emerged as a key driver of food security and rural prosperity in Bihar, yet its full potential often goes untapped due to a mix of climatic unpredictability, soil-related constraints, and conventional farming approaches. Based on extensive on-farm experience across major maize-growing districts, this article highlights practical field-level strategies that have proven effective under real farming conditions. From optimizing sowing time and planting methods to choosing suitable hybrids and improving water and nutrient use, several factors have been identified that distinguish higher-yielding fields from others. The insights presented here aim to guide farmers towards more productive, resilient, and sustainable maize cultivation practices.

Keywords: Food security, Resilient, Winter maize

WINTER maize, during the last one and a half decades, has become an essential component of agricultural productivity in Bihar. It is considered a viable option for crop diversification and an important source of additional income for rural households. Its adaptability and relatively short growth duration make it especially popular among farmers, particularly in regions vulnerable to climatic variability. For winter maize specifically, yield gaps in Bihar range from 3.0–14.0 tonnes/ha, depending on farmers' management practices and resource access. This indicates a substantial scope for productivity improvement through better agronomic strategies. To realize its full potential, narrowing this gap demands an integrated approach involving timely sowing, selection of climate-resilient high-yielding varieties, efficient irrigation and nutrient management, and adoption of appropriate planting methods. This article is based on two years of comprehensive on-farm experimentation conducted during 2021–22 and 2022–23 across



160 farmers' fields in 20 villages of Purnia and Katihar districts, Bihar, covering diverse agro-ecological conditions including upland and lowland areas to document existing agronomic practices and associated yield variability under real farming conditions. Ten villages were selected from each district, representing a mix of upland and lowland conditions, varying resource availability, and exposure to climatic variability. The villages included locations such as Musapur, Basgarah, Sisiya,

and Mahinathpur in Katihar and Dogachhi, Dholbazza, Sadalpur, and Ranipatra in Purnia. These field sites formed the basis for evaluating winter maize yield variability and associated agronomic practices under real farming conditions. The study systematically assessed the impact of key agronomic practices such as sowing windows, variety selection, planting methods (raised vs. flat beds), seed treatment, spacing, tillage frequency, irrigation hours, and nutrient application

strategies. Farmers were classified into high, medium, and low yield categories, with observed yields ranging from 9–14.00 t/ha. Based on these real-field insights, this article presents practical, evidence-based strategies to enhance winter maize productivity and strengthen resilience against climatic and environmental challenges in Bihar.

Optimal sowing time

The sowing date for maize determines its yield; hence, it is considered one of the most critical decisions in agro-ecology within regions with varied climatic backgrounds like Bihar. It identified the ideal window for winter maize sowing as between October 25 and November 7. During this window, soil moisture is usually available, and the temperature conditions are favourable for seed germination and emergence of early stages of growth. Indeed, the yield data that accrued throughout the two-year duration of the study consistently showed that maize sown within this period scored better yields, very commonly touching up to 12 t/ha, sometimes even touching 14 t/ha. In contrast, a delayed sowing experiment done in late November and December over the same period recorded yield reductions of as high as 36%. These findings clearly show that the timely sowing is highly essential to take full advantage of the favourable season. However, in practice, smallholder farmers find it difficult to adhere to the sowing window due to labour shortages or other logistical reasons. But, the advantage of timely sowing can clearly be seen from the difference it makes in overall productivity. Farmers are encouraged to plan well in advance and mobilize whatever resources necessary toward ensuring planting occurs within this window.

Varietal selection: Choosing high-yielding hybrids

The other important factor which influences yield is the variety to be used. In this study, different hybrids of maize were tested for their performance in agro-climatic and soil conditions of Bihar. Of all

the varieties tested, P 3355, Grover 4455 and Srikar 1818 were the top performers yielding high and locations tested during the study period. These hybrids displayed high yield potential, endurance against biotic stresses like pests and diseases, besides abiotic stresses such as drought and heat. This is very important in a region like Bihar where the climate is quite unpredictable and, to say the least, quite risky. In fact, farmers have very little access to external inputs like pesticides and fertilizers. Selection of high yielding varieties that are tolerant to stresses reduces the reliance on chemical inputs, adding to sustainability. This may imply lower production costs and increased profitability. Moreover, food security can be further enhanced using locally adapted varieties that ensure stable production even under difficult conditions.

Raised bed planting

Sowing of maize on raised bed has indeed given very positive signal towards improving maize yields, especially in low land areas frequently prone to waterlogging. It could be observed from the study that Raised Bed Planting (RBP) could reduce the risk of waterlogging owing to enhanced drainage and root zone aeration. As a result, healthy root development and a stronger plant growth took place.

In these trials, RBP has generally outperformed traditional Flat Bed System (FBS), with an increase in yield up to 13.4%. The yield gains from RBP were more pronounced under waterlogging or poorly drained soils. Hence, farmers can reduce the risk of crop failure due to waterlogging usually common in many parts of Bihar by adopting RBP. Besides the water management advantage, RBP improves soil structure favouring root growth. Though, this transition from FBS to RBP may require some initial investment in the form of equipment and training; the gains it will create in terms of yield improvement and risk reduction in the long run will be worth the farmer's investment for improvement of maize production.

Seed treatment: Boosting early plant vigour

Seed treatment is the application of protective agents such as fungicides and insecticides on seeds prior to planting. Although in this study, the effect of seed treatment on yield was not statistically significant, however, treated seeds were associated with a 20.7 per cent higher yields. The advantages of seed treatment are much more pronounced at the early stage of establishing the crops. The treated seeds are well-sheltered from the soil-borne pathogens and pests causing severe injury at seedling stage of the plant. Minimizing the



Yield performance of P3355 maize hybrid with cob vigour observed on farmers' fields at Dogacchi Purnia

Table 1. Impact of key agronomic practices on winter maize yield in Purnia and Katihar (2021–23)

Agronomic Practice	Observed Options	Avg. Yield (t/ha)	No. of Farmers	Key Technical Insights
Sowing Window	25 Oct – 7 Nov	12.65	62	Early sowing consistently achieved >12 t/ha; delayed sowing (post 15 Nov) reduced yield by up to 36%.
	5 – 15 Nov	10.52	52	Moderate sowing led to average yields.
	15 – 25 Nov	9.06	46	Late sowing reduced yield due to poor establishment.
Hybrids	P 3355, Grover 4455, Srikar 1818	12.50–14.00	68	High-performing hybrids consistently yielded >12.5 t/ha.
	P 3355, Grover 4455, Srikar 1818, DKC 9165, P 3378	9.0–14.00	57	Medium to low yielders with less adaptability.
Planting Method	Raised Bed Planting (RBP)	12.40	88	RBP showed 13.4% yield advantage; reduced waterlogging and improved root health.
	Flat Bed Planting	10.00	72	More prone to waterlogging; lower yields observed.
Spacing (cm × cm)	50 × 22	12.50	74	Wider spacing improved cob size and air circulation.
	< 40 × 20	9.30	56	Dense spacing led to smaller cobs and competition.
Tillage Operations	6–7 passes	12.65	60	Moderate tillage ensured better tilth; excessive tillage reduced yield by ~66.7%.
Irrigation (season total)	60–75 hours	12.10	66	Optimal range under RBP; saved ~15.5% water compared to flat beds.
Fertilizer Dose (NPK)	243.85–165.51–106.74 (kg/ha) + Zn + S	12.80	48	Balanced macro- and micro-nutrients crucial for achieving peak yield.

possibility of an early loss, it helps to establish a very even and healthy crop stand, which is paramount for securing high yields. Reductively, seed treatment provides a rather inexpensive method for enhancing crop robustness and yield in states like Bihar, where farmers may also be confronted with serious soil health or pest pressure challenges. While the initial application cost of seed treatment, it may be a limiting factor for some farming operations, the possible yield advantages make the treatment a valuable part of an integrated crop management approach.

Spacing and tillage

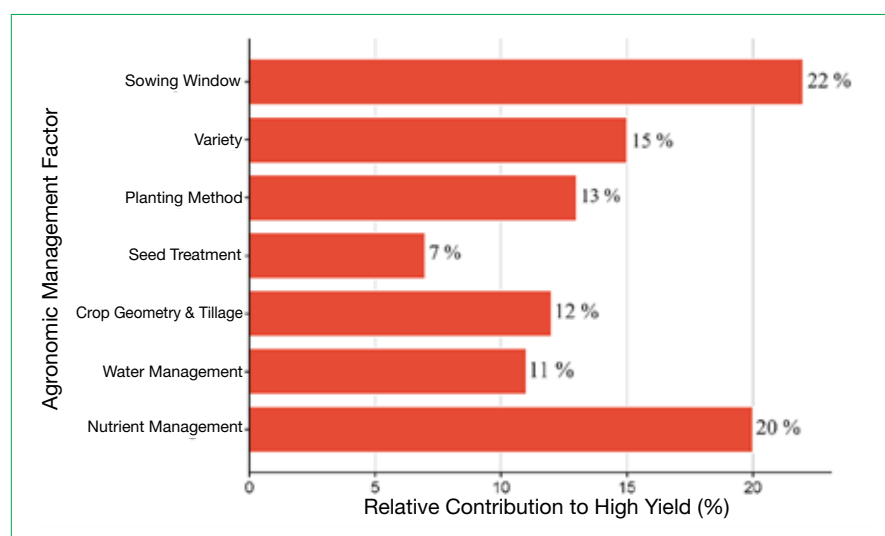
Proper spacing and land tillage are the essentials to be followed for maximum production. A row-to-row spacing of 50 cm with 22 cm spacing within a row had given excellent plant growth that had ill effects on yield, under trial. Spacing

in such a manner allows each plant to get sufficient light, water, and nutrients by reducing competition and allowing the plants to grow effectively. Tillage recommended in the study was moderate, averaging

about six tillage operations per season. Excessive frequency of tillage deteriorates the structure of the soil through compaction, hence reducing water infiltration into the soil. On the other hand, too little tillage would leave the soil with a poorly prepared seedbed for planting and often results in uneven crop stands and lower yields. Moderate tillage ensures that soil structure is maintained along with the conditions for preparing a seedbed are also achieved. This is a proper balance to ensure the best beginning of maize plants, which is very important for increasing yields. Farmers should therefore try to adopt the most suitable tillage practices for their respective soil types and environmental conditions, while care must be taken to avoid over-tillage, which will adversely impact their soils in the long run.

Irrigation management

Among all other factors, water management is the most decisive variable during maize production. It was suggested that high yielding plots use around 80 to 100 hours per hectare for irrigation. This falls right on target with peak growth times, such as germination, vegetative growth, and grain filling. Raised Bed Planting (RBP) is relatively water-efficient with less number of irrigation hours but with high yields. This partly explains the fact that under the RBP technology, there is an improved aeration,



Estimated contribution of agronomic management factors on winter maize yield in Bihar (2021–23)

soil structure, and drainage to allow for more efficient use of the available water. In case of limited water supply, adoption of RBP will make farmers save water use with sustaining or improving maize yield. Efficient irrigation management will be able to optimize the use of water by ensuring that crops get adequate amounts of water at the right time. Over-irrigation can result in waterlogging and nutrient leaching, while too little irrigation can result in plant stress and yield reduction. Farmers are encouraged to closely monitor soil moisture and adjust irrigation to ensure optimal performance of crops.

Nutrient management

Balanced use of all nutrients is crucial for realizing high yields in maize. High yielding plots were estimated to need 243.85 kg/ha nitrogen (N), 165.51 kg/ha phosphorus (P), and 106.74 kg/ha potassium (K). All these nutrients are crucial for plant growth and development. Their availability in soil needs to be properly managed to avoid deficiency or imbalance. More specifically, in plots that had low yields, over-application did nothing to increase yields. Apart

from that, over-application can also lead to negative environmental consequences like nutrient runoff and water pollution. This again highlights the advantages of soil testing and precision nutrient management in ensuring that crops receive adequate amounts of nutrients for healthy growth and high yields. Regular testing of the soil is always promoted among farmers to know the nutrient status of their fields and apply fertilizers accordingly. It helps farmers to use inputs more judiciously and with less wastage, hence contributing to better sustainability of farming.

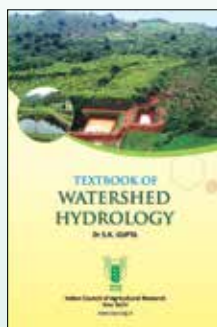
SUMMARY

Timely sowing of high-yielding hybrids and the adoption of raised bed planting techniques are critical for unlocking the full potential of winter maize in Bihar. On-farm trials conducted across 160 farmers' fields in Purnia and Katihar districts revealed that the maize yield ranged from 9.06 to 14.00 t/ha, highlighting a substantial yield gap of nearly 3.6 t/ha between low- and high-performing farms. Hybrids such as P 3355, Grover 4455 and Srikar 1818 consistently produced higher yields, while raised bed

planting (RBP) offered up to 13.4% yield advantage over flatbed systems, especially in waterlogged conditions. The application of a balanced fertilizer dose, 243.85 kg/ha of nitrogen, 165.51 kg/ha of phosphorus, and 106.74 kg/ha of potassium, was found essential for achieving optimal yields. Moderate tillage (median 6 operations) and ideal spacing (50 cm × 22 cm) further enhanced crop performance. Although seed treatment was not statistically significant, it led to a 29.2% higher frequency of high-yielding plots, supporting early vigour and crop uniformity. Among all agronomic factors analyzed, sowing window (22%) and nutrient management (20%) emerged as the most influential contributors to high maize yield, followed by variety selection and planting method, highlighting the need for precision in these practices. Collectively, these practices help bridge the observed yield gaps and contribute to higher productivity, resource efficiency, and greater climate resilience in Bihar's maize-based farming systems.

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