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Practices and Technologies for the Management of Key Maize Production Constraints during *Kharif* Season in East Champaran District – Review

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Maize production is affected by numerous biotic and abiotic related challenges in East Champaran District, Bihar State, India. The damages caused by these challenges are influenced by the season; high prevalence during Kharif season compared to Rabi season. The solution to these constraints calls for enhanced research-extension-farmer linkages to ensure better development and dissemination of technologies for adoption. Among these constraints, research should target developing varieties that are tolerant to water-stress, fall armyworm, stalk borer and aflatoxin attacks; and better site-specific soil infertility management. Besides, solutions to technical challenges like inappropriate maize spacing, poor and untimely weed control, use of local maize cultivars, poor storage methods, are already available and could effectively be managed through the use of extension agents to train and diffuse them among farmers.

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Introduction

Maize (*Zea mays,* L.) is the third most important food crop after rice and wheat with a production of about 28.72 million tons in 2017 in India.[1] The crop is traditionally produced in Madhya Pradesh, Uttar Pradesh, Jharkhand, and Bihar States which account for about 50% of the total national maize production (Figure 1).[2] Nationally, the crop contributes about 9% of the national food basket and generates about 100 billion to the agricultural GDP.[3] This is due to the important roles it plays in the manufacturing and processing industries: 55% of total production is consumed as livestock and poultry feeds while only 25% for human consumption and about 11% for other industrial purposes.[4]

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Bihar State is one of the most important traditional maize producing regions in the country with about 712000 hectares of land under cultivation and producing about 2,820,000 tons.[5] The average maize yields are higher at Bihar State (about 4 t/ha) compared to the national level (3.1/ha) [1,6] This yield difference is majorly due to the higher yields realized under *Rabi* season- season usually runs from October to March. Otherwise, during the *Kharif* season that runs from May/June to September, farmers get, on average, 2.4 t/ha.[7]

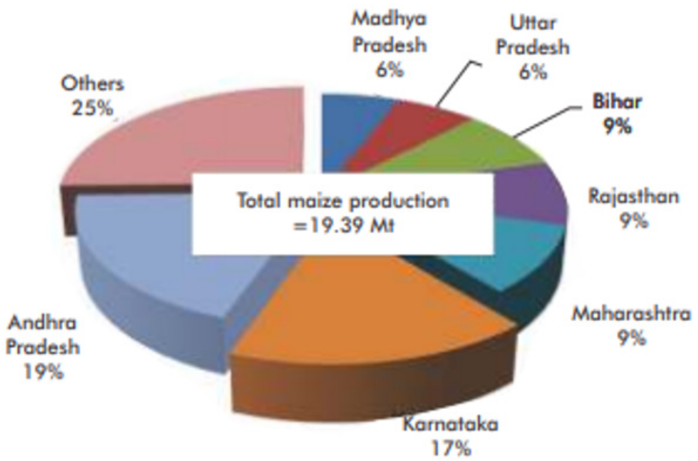

Fig. 1: Major maize producing states in India. Source: Kumar *et al.,*[7]

East Champaran District is a key producer in Bihar State with a yield range of 2-4 t/ha according to Economic Survey carried out between 2010 and 2011 in Bihar (Table 1).[8] Like other Districts, East Champaran has *Rabi* and *Kharif* seasons with extensive maize production occurring in the *Rabi* due to the absence of floods, and waterlogging conditions, low prevalence of pests, and disease.[7] Among other districts (Figure 2), East Champaran has showed declined maize production trend in recent years. This decline is attributed to increasing drought frequencies, the occurrence of floods and waterlogging, weed infestations, field pest and disease attacks, soil infertility and high post-harvest losses.[4,9,10,11] The above challenges could be managed better through research prioritization and use currently existing technologies.

Table 1: Classification of maize producing districts based on yield category in Bihar State. These districts contribute more than 1% of the maize area in Bihar State. Source: Government of India[8]

Yield category	Districts	% share of total maize acreage
High maize productivity districts with grain yield more than 4 t/ha.	Samastipur, Saharsa, Supaul, and Araria	20.0%
Medium maize productivity districts with grain yield ranging 2-4 t/ha	Nalanda, Siwan, Gopalgani, West Champaran, East Champaran, Muzaffarpur, Vaishali, Darbhanga, Begusarai, Khagaria, Bhagalpur, Banka, Madhepura, Purnea and Katihar	68.6%
Low maize productivity districts with grain yield below 2 t/ha	Patna, Saran, and Munger	6.4%

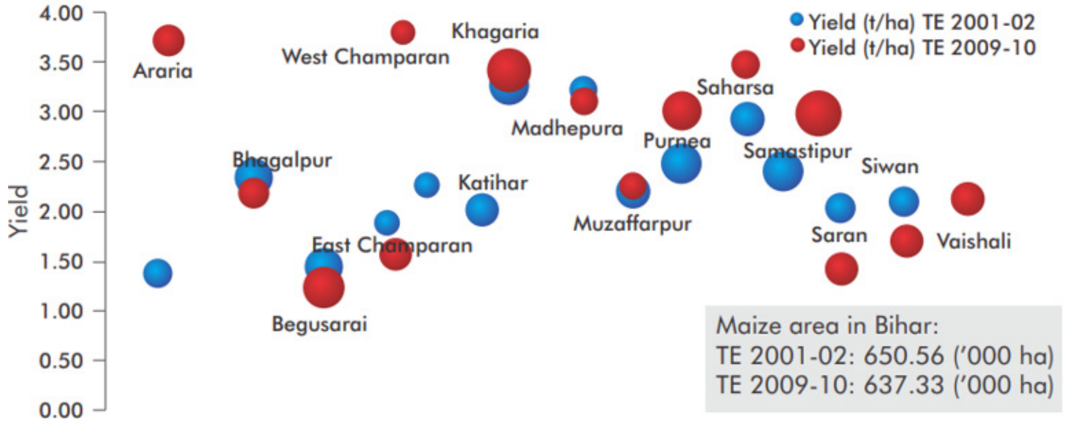

Fig. 2: Changes in the area planted with maize area and the yields among major growing districts of Bihar State. Source: Kumar *et al.,*[7]

Available Technologies and Practices for the Management *Kharif* Maize Production Challenges

Proper Variety Selection

Short maturing varieties (<85 days) are available and recommended for the Kharif season.[7] Available varieties for adoption include; D 994, Dewaki, Birsa Vikas Makka 2 (composite), Vivek 27 and Parkash, X 3342 (hybrid).[3] A more site-specific variety recommendation with better tolerance to drought and other prevailing constraints are required for increased yields.

Early and Proper Land Preparation

Proper and timely land preparation should be taken seriously to allow for better weed control and loosening of soil for better water infiltration. Depending on the condition of the land, available tools and equipment and financial situation, three cultivations (1 plowing and 2 harrowings) of land before planting is recommended for proper early weed control and aeration of the soil. Farmers should pay attention to the local weather forecasting for better timing of farm activities. Adoption of zero tillage technology is also recommended and could increase yields by up to 11 % [12,13] To manage water-logging in the frequently affected regions, farmers should be encouraged to practice the use of raised planting beds for maize production. This practice has been reported to reduce waterlogging and increase yields by about 18%.[14]

Timely Planting and Optimal Plant Density

About 2-4 weeks of planting window from the onset of rains is recommended for maize production.[9,15] Planting during the first effective rains helps in reducing chances of early droughts affecting maize at critical periods. Based on rainfall and drought frequencies, economic optimum maize density should be achieved to avoid competition for the water resource: About 65,000–75,000 plants/ha with a spacing of 60-75 cm x 25-20 cm (20-22 kg seeds/ha) is recommended for the monsoon season.[7,16]

Better Nutrient Application and Management

Intensive soil analysis is required to provide information concerning soil fertility status. Adoption of partial organic farming (application of manure/compost with inorganic fertilizer) is recommended and could help in reducing maize fertilizer requirements by 25-50%.[12] According to Kumar and Bhatt,[17] about 5-15 t/ha of animal manure is recommended for application in the region. The application of manure should be done during land preparation to allow for proper incorporation, early mineralization and release of nutrients. Application of inorganic fertilizers provides an immediate solution to soil infertility. For hybrid and composite varieties, 100-120 kg of nitrogen, 60 kg of P_2O_5 and 40 kg of K_2O per hectare is recommended for the region.[17] Looking at the nutrient extraction levels and responses by maize, application of 50 kg DAP, 50 kg MOP and 180 kg urea per hectare could provide the improved economy package for the farmers who have financial challenges. For a more optimized production, increasing N rate from 180 kg urea to 225 kg urea per hectare could be feasible and more profit-maximizing. To reduce nutrient use inefficiencies, all fertilizers should be spot-applied and covered with soil to minimize losses.

Adequate Water Supply and Management

For sustainable management of floods, adoption of tolerant varieties should be encouraged. Few varieties are however claimed to be tolerant to waterlogging. In a neighboring country of Bangladesh, Uttaran-2, 900M Gold and Pinacle hybrids have been found to be suitable for production in flooding conditions.[18] These accessions/varieties could be trialed for adaptation and release to farmers in East Champaran District. Use of raised planting beds for maize production in areas prone to flooding is also an adaptable strategy.[14] Soil and water conservation measures like zero tillage; mulching through the retention of crop residues after harvesting, intercropping with cover crops should be encouraged among producers to help in reducing excessive evapotranspiration.[19,20, 21,22] To farmers with already existing irrigation system, supplemental irrigation should be used to bridge water deficit occurring during maize growing periods- the frequency and amount of water required would depend on the period of drought and stage of occurrence.

Better Maize Agronomy and Weed Management

The most important aspect of weed control involves a proper understanding of the crop's critical growth periods for weed control. The critical period for weed control in maize is 3 to 14 leaf stages (equivalent to 19-55 days after emergence).[23,24] To apply the concept, farmers should be trained on and encouraged to carry out two weedings per season of maize production- first weeding at V_4 and second weeding at V_6. Maize-legume intercrop and rotation systems have also been found to significantly reduce weed seed bank, weed population and density thereby increasing maize yields.[6,25,26, 27] Therefore, when included in the maize cropping cycle, the crops could ensure sustainable weed management apart from providing additional food to the household members. To adopt this practice, farmers should be advised to include common legumes such as chickpea, grams, cowpea, and lentils in their cropping systems. In addition to soil water management, combined no-till with crop residue retention has also been reported to significantly reduce weeds in maize fields.[28] Pre-emergence and post-emergence herbicides could also be used to help in keeping weed densities below the economic threshold.[29,30,31] Use of herbicides reduce weed density and improve yields significantly.[32] Proper selection and use of these herbicides should follow the current best practices to reduce any health and environmental risks.[33]

Pest and Disease Management

Control of pests and diseases should be within the sustainable and eco-friendly sphere as defined by the Integrated Pest Management (IPM) strategy. Various cultural and agronomic practices have been recommended for control of these pests and diseases: Planting of certified seeds every season, proper field hygiene through clearing of previously infected crop residue and timely roguing of infested plants are among the best cultural practices that check on the buildup of pests and disease. Crop rotation and intercropping with common legumes like chickpea, lentils, and grams improve soil health and help in the management of these pests by breaking their life cycles.[34] Balanced maize crop nutrition and adequate water supply are important agronomic practices that ensure vigorous growth and increase crops tolerance levels to attack. Proper and timely weed control could also help in reducing host survival and competition for growth factors. Also, the push-pull technology, involving intercropping of maize with desmodium and having Napier as edge crops, has been hailed and recommended for the management of fall armyworm, stalk and cob borers.[35,36] This technology also helps in improving soil fertility. Various strategies for sustainable control of termites have been provided for adoption by Otieno.[37] Use of chemical compounds provides quick restoration of the situation. For instance, chemical products such as chlorantraniliprole 20 SC for control of borers and other pests of the same family member,[38] and Mancozeb and Metalaxyl for control of general fungal diseases are available for use in the region. When using these chemical care must be taken to reduce health risks and to increase efficacy.[33]

Timely Harvest and Proper Postharvest Management and Storage of Maize Produce

Farmers should harvest their maize immediately they are mature and continue drying them on hard surfaces and/or drying sheets to reduce moisture contents to below 14% for safe storage. Proper drying to moisture levels below 14% and sorting out holed and discolored grains should be done before storage to reduce the transfer of pests and diseases into the storage bags. Adoption of hermetic bags like PICs/ Super Bags and steel Silos are recommended for keeping off moisture and grain borers during storage.[39] Farmer sensitization on the effect of aflatoxin in the body and livestock needs to be taken seriously to help curb consumer toxicity. Control of aflatoxin through breeding for tolerant varieties should be prioritized. Use of modern technologies like Aflasafe has shown high efficacy in the control of *Aspergillus flavus* and *Aspergillus parasiticus* fungi. According to Bandyopadhyay *et al.,*[40], the aflasafe technology is capable of reducing aflatoxin concentrations in treated crops (like maize and groundnut) by more than 80% in comparison to untreated crops in both field and storage conditions.

Conclusion

Maize production is affected by numerous biotic and abiotic related challenges in East Champaran District. Most of the solutions to some of the technical constraints (such as inappropriate plant spacing, poor and untimely weed control, use of local maize cultivars and high postharvest losses) are already available and only require strong extension-farmer linkage to ensure a steady flow and adoption. Management strategies such as the use of inorganic fertilizers, development of drought, aflatoxin, stalk borer, and fall armyworm tolerant varieties require more region-specific research for better adoption and efficiency in the control.

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Conflict of interest

The author declares no conflict of interest.

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