

Crop Diversification in Rice-Wheat Cropping System with Maize in Haryana



ICAR-Agricultural Technology Application Research Institute

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(ISO 9001-2015 Certified Institute)

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Contents

1. Introduction	1
2. Adverse effect of rice cultivation	2
3. Advantage of maize cultivation over rice	8
<i>a. Water-saving</i>	8
<i>b. Energy saving</i>	8
<i>c. Environmental benefits</i>	9
<i>d. Cropping system optimization</i>	9
<i>e. Reducing maize import</i>	10
<i>f. Enhancing livestock productivity</i>	11
<i>g. Peri-urban agriculture</i>	11
<i>h. Agro-industrial growth promotion</i>	11
<i>i. Mechanization and conservation agriculture promotion</i>	12
<i>j. Nutrient use efficiency</i>	12
<i>k. Employment generation and entrepreneurship</i>	12



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1. Introduction

Rice is the major crop in Haryana, its area increased from 1.92 to 14.22 lakh ha, and production increased from 2.23 to 45.23 lakh tonnes during 1966-67 to 2020-21. Since the late sixties, the introduction of high yielding varieties of rice and expansion of irrigation and electricity facilities assured procurement as favourable government policies boosted rice cultivation. At present, rice based cropping systems in agriculture had predominated in Haryana. The traditional maize cultivated site was also occupied by rice cultivation shifting of the area site was accelerated due to the non-availability of high yielding cultivars in maize.

However, rice has expanded in the region's with limited water availability and less rainfall that caused the water table to decline at an alarming level as rice is recommended in the areas receiving rainfall more than 800 mm. The rice cultivation was the need of the hour to ensure the nation's food security and helped bring food self-sufficiency and farmers prosperity.

The burning of crop residue contributes to atmospheric pollution with severe environmental, soil, and human health and economic implications. It releases large amounts of air pollutants and heat generated soil temperature, causing the death of beneficial soil microbial population. It also reduces the level of nitrogen and carbon in the top 0-15 cm soil profile, which is essential for crop root development.

Burning the crop residue causes phenomenal pollution problems in the atmosphere and substantial nutritional loss and physical health deterioration to the soil. Burning of one ton of paddy straw release 3 kg particulate matter, 1460 kg CO₂, 199 kg



ash, and 2 kg SO_2 . These gases affect human health due to the general degradation in air quality, resulting in aggravation of eye and skin diseases. Fine particles can also aggravate chronic lung diseases. One ton of paddy straw contains approximately 5.5 kg N, 2.3 kg P_2O_5 , 25 kg K_2O , 1.2 kg S, 50-70% of micronutrients absorbed by the rice, and 400 kg of carbon are lost due to the burning of paddy straw. Apart from the loss of nutrients, some soil properties like soil temperature, pH, moisture, available phosphorus, and soil organic matter are greatly affected due to burning. Nonetheless, the time available between rice harvesting and wheat sowing is very narrow (in the range of 20-30 days).

However, rice cultivation in similar fields has created some serious problems and environmental threats, *viz.* The declining water table, enhanced groundwater pollution by nutrient and pesticide leaching, affected soil physical properties and soil biodiversity, enhanced greenhouse gas emissions, rice residue burning to result in environmental pollution etc.

2. Adverse effect of rice cultivation

- ❖ Groundwater level depleted by 1 m/year since 2013
- ❖ Underground water level has plunged by 20-60 meters in 19 of 22 districts of Haryana due to non-conventional rice (<1200 mm rainfall area)



- ❖ More 'Dark Zones' as Ground Water Dries Up Rapidly
- ❖ Canal waters and groundwater salinity led to waterlogging.
- ❖ Groundwater pollution by leaching of nitrate and agrochemical
- ❖ Depletion of soil physical health, environmental pollution, underground water contamination, loss of biodiversity
- ❖ Favoured incidence of pest (weed, disease etc.)
- ❖ Human and animal health affected due to excessive use of agrochemicals.

An urgent need is felt to reduce the area under rice. Diversification of it with remunerative, less risky, and eco-friendly crops can provide substantial income and help to address many of these problems. Maize has the potential to emerge as the most appropriate substitute, which can bring more prosperity to the farming community without adversely affecting natural resources. It has also added the advantage of saving precious resources like water and electricity.

Maize was a major crop in North Eastern Haryana until the 1970s in the *Kharif* season, having more than 1.7 lakh ha in Karnal, Ambala, Kurukshetra, Yamunanagar, Panipat etc. Due to raw material availability, the country's first starch industry was established at Yamunanagar in 1937. However, because of our emphasis on rice and wheat to ensure the nation's food security, the promotion of maize in an irrigated state like Haryana could not get due attention.

At present, due to increased adverse consequences of rice cultivation and promising innovations in maize research and development, and availability of technical know-how, it is high time to promote maize cultivation in the state to prevent further deterioration in natural resources and to ensure the long-term sustainability of agricultural development in the state.



Maize is the only crop with many types like dent corn, flint corn, sweet corn, QPM, baby corn, popcorn, fodder maize etc. Maize cultivation leads to improvement in soil health and biodiversity. Utilization of maize is primarily in poultry and livestock/feed, starch, value addition etc. It also addresses *peri-urban* agriculture issues by cultivating baby corn, sweet corn, and vegetable intercropping systems. The export-oriented agriculture hubs can be established for feed, baby corn, sweet corn etc., for employment generation in specialty corn and value addition. Maize helps livestock promotion using by-products of sweet corn, baby corn, fodder maize, feed blocks and silage making for livestock and export to neighbouring states.

Presently, after an accelerated hybrid maize development programme in the country and the state, a good number of hybrids with high yield potential are now available both at public and private sector research organizations. These hybrids have performed well and competed with rice with the lesser cost of cultivation and low water requirement. It has helped in reversing all the adverse effects of rice cultivation by reducing groundwater decline, enhancing input productivity and lesser environmental pollution. Maize being a C_4 plant, has an advantage over rice for energy saving, and the environmental benefit associated with maize can be used for future carbon trading.

These hybrids have immensely benefitted the farmers of India, especially the Peninsular and Eastern India. The other less remunerative crops like upland rice, winter rice, cotton, sorghum, sugarcane of these ecologies were diversified with maize. After adopting hybrid maize, more than 30 lakh ha area has been shifted from these crops to maize in the different parts of the country (Maharashtra, Madhya Pradesh, West Bengal, Odisha and Tamil Nadu).

As a result, the rice-rice ecologies of peninsular and eastern India have taken an enormous lead in maize cultivation. The maize is traditionally grown in northern and central India, but now the significant share comes from Peninsular and eastern India with productive maize hybrids. It helped in enhancing the income of the farmers in these ecologies with water-saving. The poultry and starch industry also flourished during the past few decades, which consumes more than 85% of the country's maize. India again turned from an importer to an exporter of maize and its products.

Table 1. Advantage of maize cultivation over rice

S.No.	Parameters	Rice	Maize
1.	Water requirement	Very high	Low (8-times lesser than rice)
2.	Water productivity	Low	High
3.	Residue burning	Residue burning results in environmental pollution and degrades biodiversity.	No such problem
4.	Groundwater pollution	Nitrate and pesticide leaching.	No such problem
5.	Duration	Long	Short (at least 20 days lesser than rice)
6.	Planting/crop establishment	Cumbersome and labour consuming, nursery and transplanting	Easier (only direct seeding)
7.	Per day productivity	Less	Higher
8.	Mechanization	Partially mechanized	Fully mechanized



S.No.	Parameters	Rice	Maize
9.	Soil physical health	Degrading crop	Restoring/improving crop
10.	Use of agrochemicals	More leaching	Less leaching
11.	Cropping system optimization	Subsequent crops are affected and result in low system productivity and profitability.	Subsequent crops benefitted and resulted in higher system productivity and profitability.
12.	Climate resilience	A photosynthetically less efficient C ₃ plant due to high photorespiration under increased temperature increases GHGs (methane, nitrous oxide) emission.	A photosynthetically efficient C ₄ plant has no photorespiration under high temperature, and its cultivation results in lower GHGs emissions.
13.	Policy intervention	Assured procurement at MSP.	Presently no such policy.
14.	State requirement/demand	Surplus	Highly deficit
15.	Use of biomass/residue	High silicon deters for livestock, collection, and burning due to less turnover time for wheat seeding.	Green fodder used for animal fodder, easy dry fodder collection, easily decomposable, can be kept on the soil surface with zero-till planting, or can be used for mushroom production.
16.	Livestock promotion	Not much scope is mostly used for food, and straw unsuitable for livestock.	Broader scope for livestock promotion as green fodder, silage, and grain for feed. The silage can be used for



S.No.	Parameters	Rice	Maize
			grazing/feeding livestock at any stage of crop growth. It also has no risk of any anti-nutritional compound.
17.	Poultry industry growth	Less suitable.	Most suitable as a primary feed ingredient.
18.	Value addition	Lesser opportunity due to more direct food consumption	More opportunity as 1000s of the products can be made from different types of maize.
19.	Export opportunity	Only basmati has a competitive market.	Grain, feed, starch, and baby corn have great potential for export in neighbouring countries and high-value developed economies due to the low cost of internal production and high external demand.
20.	Conservation agriculture	Very less scope	Highly suitable for conservation agriculture.
21.	Electricity and power/energy	Very high requirement	Very less requirement
22.	Transportation cost of commodity	non-basmati rice used in PDS incurs enormous transportation costs.	The extra cost of transportation incurred in the import of maize from other states increases the industry's raw material cost.
23.	Handling and post-harvest losses	High, extra infrastructure for the storage of surplus rice is required.	Low, no carry stock due to shortage in the state and multiple industrial uses.

S.No.	Parameters	Rice	Maize
24.	Silage	Not suitable	The best material for making silage can be used in livestock and exported after meeting the internal requirement.
25.	Intercropping scope	Not suitable	The most suitable crop for growing pulses, vegetables, and flowers is due to the crop's wide-spaced rows.
26.	Dietary diversification and nutritional security	Lesser opportunity	Quality protein maize can be integrated into the diets of all group people for nutritional security.
27.	Overall cropping system profitability	Less	More

Therefore, it is crucial to extend the benefit of maize diversification to Haryana farmers considering the progress made by the other states. The salient advantages of diversification through maize cultivation are given below:

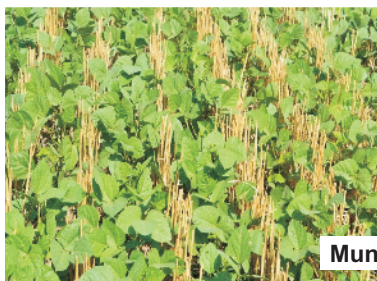
3. Advantage of maize cultivation over rice

- a. Water-saving:** The maize expansion will help check the groundwater declining/saving of the water, which can be used to enhance cropping intensity and expand irrigated areas in other crops, to produce 1 kg of rice, 4000 liters of water required. Thus, the **saving of water to the tune of 90% by maize cultivation** instead of paddy (Maize Summit, 2018).
- b. Energy-saving:** The rice cultivation requires at least 35-40 irrigation, and maize requires only 4-5 irrigations, and therefore the saving of the energy of at least 8 times in

groundwater pumping can be diverted for the smooth running of the industry. The **maize cultivation saves 70% power** as compared to paddy (Maize Summit, 2018).

- c. Environmental benefits:** Maize cultivation also brings several ecological benefits like reducing greenhouse gas emission, solving the problem of residue burning, improving soil physical properties and biodiversity, lesser groundwater pollution etc. It will help in an overall improvement in environmental quality leading to improved quality of life. The biomass of maize is easily degradable compared to rice due to less silicon content and, therefore, improves the soil's organic matter content.
- d. Cropping system optimization:** The optimized maize duration allows subsequent crops and results in higher system productivity and profitability by following maize-wheat-mungbean (MWMb), maize-mustard-mungbean (MMMb), maize-autumn/ winter/summer vegetable systems.
 - i. Enhanced wheat production:** Wheat is the most crucial *rabi* crop in Haryana, which occupies the highest acreage (~2.5 million ha) in the state, and its productivity is critical for the state agricultural economy. Maize takes less time than rice that advances the wheat planting and thereby increases its productivity and production by ensuring increased crop duration and avoiding the risk of terminal heat stress.
 - ii. Opportunity for mustard cultivation:** Similarly, in mustard, it gives timely planting and reduced risk of aphid infestation, which enhances its productivity.

- iii. Summer mungbean:** Further, the third mungbean crop can be taken with a shorter duration and more yield for enhancing soil fertility.



- e. Reducing maize import:** Haryana has a substantial presence of maize-based agro-industries (feed, starch, food processing etc.), and they are mostly dependent on maize from other states, which enhances the cost of production of these

enterprises and thus erode their competitiveness. The local production will improve their efficiency and competitiveness. The procurement of maize will also generate revenue and employment for the state.

- f. Enhancing livestock productivity:** Green fodder is in great demand in the state and the nearby states. Maize is the best quality green fodder, and silage preparation can be used to enhance livestock productivity in the state and be transported to neighbouring states. The stover of stay green maize hybrids can also be directly used for livestock feeding.
- g. Peri-urban agriculture:** Haryana is blessed with several high-end metropolitan cities, which offers an excellent opportunity for specialty corn (baby corn, sweet corn, popcorn), and high value/early vegetables can cultivation as sole or intercropped. Being a large part of the Delhi NCR region, these products can be utilized as fresh locally or exported out of the country or processed if surplus. The processing industry can also be established for export near the airport and sound transportation system in the state.
- h. Agro-industrial growth promotion:** The state is in the NCR region has a significant advantage of the poultry, dairy and specialty corn production in which maize can play an essential role in flourishing these industries.





- i. Mechanization and conservation agriculture promotion:** Maize cultivation is completely mechanized from sowing to harvesting. Thus, it will reduce drudgery and saving of labour used in rice transplanting. Maize is also a conservation agriculture-friendly crop and will address issues of residue burning and degrading soil health.
- j. Nutrient use efficiency:** The leaching and denitrification losses in the rice are very high, whereas these losses are significantly less in maize cultivation and thus maize cultivation will enhance the nutrient use efficiency.
- k. Employment generation and entrepreneurship:** The establishment of the corn-based agro-industry viz. feed, poultry, specialty corn, silage making, starch etc. will generate more employment and entrepreneurship opportunities state.



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