

Raised bed technology: A sustainable approach for crop cultivation

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Sowing method plays an important role in crop establishment. Raised beds is one such method which require less irrigation, and lessens the negative effects of excess water on crop productivity especially in semi-arid and arid regions. For high-value crops that are more susceptible to transient water logging stress, this system is frequently thought to be more suitable. On the raised beds, farmers frequently grow crops like corn, potato, cabbage, carrot, radish, okra, onion, brinjal, cauliflower, colocasia, turmeric, cotton, and wheat. Field research was carried out to examine the impact of sowing techniques on yield and minimise the excess use of water in farmers' field conditions. The findings suggest that a system of growing crops in raised beds could be especially beneficial in regions where groundwater levels are dropping. Intercropping and crop diversification are also easier by the tillage and crop establishment options.

Keywords: Maize, Maize + potato intercropping, Semi-arid regions, Sowing method

IN many regions of the world, agricultural productivity is constrained by challenges such as salinity, waterlogging, poor soil structure, and inefficient use of irrigation water. These limitations reduce soil fertility, restrict root growth, and increase crop vulnerability to pests. To overcome these issues, raised bed technology has emerged as a viable and efficient agronomic solution. In this system, crops are planted on elevated soil beds with furrows in between, which significantly improves root development, water distribution, soil aeration, and overall crop performance compared to traditional flat-bed planting.

The high rate of seed and labour associated with traditional sowing of large seeded crops like maize, cotton, groundnuts, and pigeon peas are among the major constraints. Raised bed technology provides a solution to these issues by enabling mechanised planting

and fertiliser application. For example, tractor-drawn raised bed planters with trapezoidal hoppers, inclined plate-style metering units, and furrow openers that position seeds at the appropriate depth have been created and tested for wheat cultivation. A ground-wheel chain-sprocket system provides power transmission to the metering unit, guaranteeing accurate and consistent seed placement.

Experiments in various agro-climatic zones showed that planting in raised beds is especially beneficial in places where groundwater is running low. The Furrow Irrigated Raised Bed (FIRB) technique has shown significant potential in saving water, nutrients, and labour, while also facilitating crop diversification and intercropping of vegetables and legumes. Overall, raised bed technology not only addresses the pressing challenges of modern agriculture but also enhances the prospects of

sustainable intensification, resource conservation, and diversification of cropping systems. Its adoption is especially pertinent in South Asian rice-wheat production systems because it offers opportunities for increased productivity, profitability, and resilience in the face of resource scarcity and climate change.

The FIRB planting method is used to plant crops on ridges or beds. The beds are maintained between 37 and 107 cm wide and 12–15 cm high, depending on the crop. For cauliflower, okra, carrot, and cabbage, the bed width is kept between 37 and 107 cm, and two to four rows are typically sown with 30 cm spacing between them. Raised bed planting has become more popular in Indo-Gangetic Plains (IGPs) over the past ten years, particularly for high-value crops and vegetables.

Permanent Raised Bed (PBR) systems

The PRBs lower land preparation costs by reducing field operation

time, improving mid-season field access to reduce weed infestation, and facilitating crop residue management through minimal tillage. The machine primary function is to create raised beds using a planter and simultaneously plant seeds of varying sizes, ranging from large to tiny on the beds. Since agriculture currently uses 92% of India's water, industry about 3%, and domestic uses like drinking water and sanitation only 5%, this technology helps to boost production, reduce production costs, and save up to 25–30% of water.

Raised beds are usually between 10 and 30 cm high. Moisture and soil texture are the main factors that determine the ideal height. For example, on clayey soils that receive a lot of rainfall and have poor drainage, raised beds are usually 20–30 cm high. Under the same circumstances, the bed height on coarse-textured soil could be between 15 and 20 cm. Raised beds have several benefits, including the ability to do field tasks like weeding, fertiliser application and thinning as well as significantly better drainage than flat beds. As they are constructed by dragging material from the nearby alleyways, they offer a thicker layer of topsoil and are therefore most likely looser than flat beds.

Water management and irrigation efficiency

The cropping bing season affects maize productivity and water management. Approximately 85% of maize is grown during the monsoon season, making it primarily a rainfed crop. Irrigating at key stages (young seedlings, knee-high stage, flowering, and grain filling) significantly increases crop yield in arid climates with guaranteed facilities. To prevent soaking ridges and furrows in the plain fields, the initial irrigation should be done with extreme caution. Water can also be saved by applying irrigation water in alternate furrows in raised bed planting systems with limited water availability. Tied ridges help retain rainwater in rainfed areas so that it

remains available in the root zone for an extended amount of time. Quick drainage should be guaranteed in areas with high rainfall or in the event of a high rainfall event in other regions because maize is extremely sensitive to water congestion and water logging.

To achieve a high yield of about 5 t/ha, the maize crop requires 44 mm of water in 0–20 days, 161 mm in 20–50 days, 207 mm in 50–80 days, and 82 mm in 80–100 days, for a total of 495 mm in 100 days of active crop growth.

Raised bed application in different crops

Raised beds in ridge-furrow systems are used to plant a variety of crops, including wheat, maize, mustard, soybeans, pigeon peas, and others. Multicrop raised bed planters are used to prepare ridges or beds, which are then reshaped and seeded for the following growing season. For high-value crops that are more susceptible to transient water logging stress, this system is frequently thought to be more suitable. By reducing the timing of irrigation by half and acting as a drainage channel during periods of heavy rainfall, irrigation using a furrow irrigation system helps save irrigation water and protect crops from excessive moisture if left in place for an extended length of time. Presence of previous crops residue in the furrow soil becomes soft, light and friable, consequently populations of earthworm increases and crop becomes healthier.

Through the use of the same inputs, such as field preparation, irrigation water, and fertiliser application, farmers are benefiting from the introduction of maize + potato intercropping. Despite the use of higher yielding cultivars, the growth in crop productivity of component crops is either declining (rice) or stagnating (wheat). Therefore, replacing rice, which uses more water, with cash crops like cotton and sugarcane or maize will not only save water but also increase system productivity, which will raise farmers' incomes. Growing of early maturing, photo insensitive, high tillering crops' varieties,

tolerant to biotic and abiotic stresses, mulching with crop residue for soil moisture Conservation, etc. can be implemented for best cropping system mode.

Benefits of raised bed planting of crops

- Reduced seed rates, water needs, and crop lodging.
- Increased crop yields, improved nitrogen use efficiency.
- Keeps the soil's surface from developing crust.
- Enhanced crop emergence and establishment by using the proper type of furrow openers, which also improve depth control and seed-to-soil contact.
- The management of irrigation water has been simplified and improved. It frequently uses 30% less water and yields 20% more crops than flatbed methods. FIRB planting saves 20% of the wheat seeds when compared to planting in a flat bed.
- Better drainage makes it feasible to produce upland crops more successfully during the wet monsoon. Better positioning, particularly top-dressing can boost fertiliser efficiency.
- During the grain filling stage, farmers can apply N and irrigation water to wheat to increase its protein content without causing lodging. Reducing lodging can have a significant, positive effect on production because many farmers do not irrigate right after leaving in order to minimise lodging. As a result, water may begin to prevent grain filling, which would reduce yield.
- Planting beds allows for irrigation before seeding, which offers the opportunity to minimise weeds before planting. Bed-planted crops can be irrigated right after seeding if pre-sowing irrigation is likely to delay planting.
- Early in the crop cycle, weeds between the beds can be mechanically managed.

Table 1. Yield and economics of raised bed planting in different crops in 2023-24

Technology	Yield (q/ha)		Economics							
			Cost of cultivation (₹/ha)		Gross returns (₹/ha)		Net returns (₹/ha)		B:C ratio	
	Demo	Local	Demo	Local	Demo	Local	Demo	Local	Demo	Local
Raised bed maize	33.12	27.82	22,480	23,100	62,580	40,100	40,100	17,000	2.78	2.27
Raised bed maize with arhar intercropping	M-30.28 A-11.62	M-27.82 A-9.23	25,680	26,890	88,380	73,970	62,700	47,080	3.44	2.75
Raised bed arhar	13.65	10.21	23,460	24,250	80,581	59,850	57,121	35,600	3.20	2.31
Raised bed wheat	31.84	29.56	46,520	44,680	88,656	82,307	42,136	37,627	1.90	1.84
Raised bed potato	212.58	141.54	1,19,750	1,24,620	3,18,870	2,12,310	1,99,120	87,690	2.66	1.70

M: Maize, A: Arhar.

Frontline demonstrations

To further illustrate the impact of raised bed technology, field demonstrations conducted on maize, arhar, wheat, and potato under different planting systems have provided significant evidence of its productivity and profitability advantages over traditional practices. The demonstrations were carried out in village Adhaura, district Kaimur during 2023-24 and 2024-25 on red laterite soil using maize var. 'P-1008'. Raised bed planting was compared with the conventional flat-bed method following the recommended package of practices. Grain yield, cost of cultivation, gross returns, net returns, and benefit-cost ratio were recorded. In maize, raised beds recorded higher yields than local practice, with improved net returns and a higher B:C ratio. Maize + arhar on raised beds further enhanced economic viability, producing 30.28 q/ha maize and 11.62 q/ha arhar, resulting in the highest B:C ratio (3.44), demonstrating the potential of raised beds for diversification and intercropping. Similar was the case in arhar.

For wheat and potato, raised bed planting also proved advantageous. Wheat yields increased modestly (31.84 vs. 29.56 q/ha), but profitability improved with higher net returns (₹42,136/ha) and B:C ratio (1.90). Potato showed the most remarkable response, with yields rising from 141.54 q/ha under local methods to 212.58 q/ha on raised beds. Overall, raised bed technology consistently enhanced productivity and profitability while conserving resources, establishing

it as a sustainable alternative to conventional crop establishment methods.

In terms of gross and net returns, demonstration plots generally outperformed local methods, although variations in cultivation costs were negligible. The most notable benefit was seen in raised bed potato (Demo), which outperformed the local potato system and all other crops, achieving the highest gross and net returns. This indicates that when better practices are implemented, potatoes grown in raised beds have a strong economic viability. When compared to arhar alone, maize + arhar intercropping (Demo) also demonstrated

increased profitability, indicating that intercropping not only improves land-use efficiency but also raises net returns. Raised bed wheat and maize, two cereal-based systems, showed a moderate level of profitability, with Demo practices consistently outperforming local. Raised bed arhar's lower market value and economic competitiveness in comparison to other systems, however, are reflected in its relatively low net returns in both demo and local practices. Crucially, the trend showed that Demo practices increased profitability more successfully than local practices, even though the B:C ratio values were generally



Field study of raised bed technology in different crops

low across all systems. This demonstrates how technological interventions, even with modest benefit-cost margins, can improve farm economics.

SUMMARY

Raised bed technology is a sustainable crop establishment technique that enhances water-use efficiency, crop productivity

and resource conservation. Its adoption offers significant agronomic and economic benefits by improving irrigation efficiency, soil conditions, and crop performance while facilitating mechanised crop management. The illustrative case study presented further demonstrates the practical advantages of raised bed technology under farmers' field conditions.

Wider adoption of raised bed technology, particularly in rice-wheat production systems and other water-limited environments, can contribute to sustainable intensification, climate-resilient agriculture, and long-term food security.

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