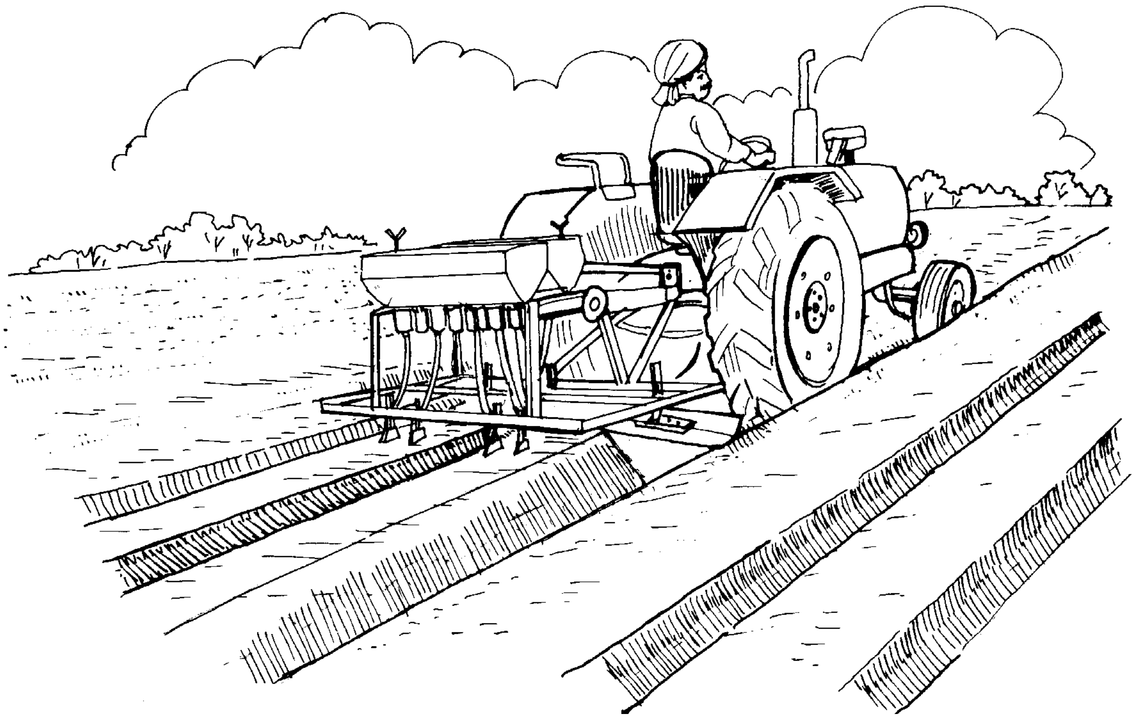
Bed Planting in Rice-Wheat System



In bed planting systems, wheat or other crops are planted on the raised beds in ridge-furrow system. This system is often considered more appropriate for growing high value crops that are more sensitive to temporary waterlogging stress. Farmers often raise crops such as cotton, maize-soybean and wheat on the raised beds. However, the practice of growing rice, the major water-using crop in rice-wheat systems, on narrow raised beds was introduced only very recently in the Indo-Gangetic Plains (IGP) to reduce water use, conserve rainwater and improve system productivity. Recent work shows that system of raised bed planting of crops may be particularly advantageous in areas where groundwater levels are falling and herbicide-resistant weeds are becoming a problem. This tillage and crop establishment option also facilitates crop diversification and intercropping of wheat, chickpea and Indian-mustard with sugarcane, maize with potato, mint with wheat, rice with soybean, and pigeon pea with sorghum or green gram. Although bed planted wheat in rotation with soybeans covered more than 75% area under wheat by 1994 in Mexico, the South Asian rice-wheat farmers are still experimenting with this system of crop planting in the IGP to address issues of receding watertables, crop losses due to temporary waterlogging in monsoon season and declining factor productivity and for crop diversification. Results of farmer participatory trials indicate that significant water savings can be effected by planting rice (major consumer of irrigation water in rice-wheat systems) on raised bed besides improvement in crop yields.

Effect of Tillage Options on Plant Attributes and Yield of Rice and Saving in Irrigation Water

Tillage options	#Experimental area (ha)	Spike length (cm)	Grains/ panicle	Saving in irrigation water, %	Grain yield (Mg/ha)
Transplanted rice on beds	12(20)	23.4	173	41.5	56.2
Direct seeded rice on flats	12(10)	21.9	163	17.8	56.9
Conventional tillage	14 (35)	21.5	163	-	52.9

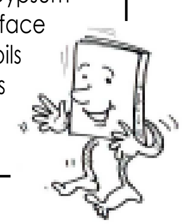
* Percent saving in water (in terms of irrigation time) when compared to farmers' practice
\# Number of farmers' participation in trials in parenthesis

Potential of Raised Beds

Change over from growing crops in flat to ridge-furrow system of planting crops on raised bed alters the crop geometry and land configuration, offers more effective control over irrigation and drainage as well as their impacts on transport and transformations of nutrients, and rainwater management during the monsoon season. In furrow irrigated raised bed (FIRB) system, water moves horizontally from the furrows into the beds (subbing) and is pulled upwards in the bed towards the soil surface by capillarity, evaporation and transpiration, and downwards largely by gravity. In determining the dimensions of the beds, factors such as spacing between tractor tyres, soil types, rainfall and groundwater conditions, salinity and irrigation water quality and requirements of crops grown in rotation are of prime importance. For developing a permanent system of bed planting, factors like irrigation and fertilizer management, crop residue management, inter-tillage and weed management must be considered together. For major soil types (sandy loam to loam soils) and crops (inter-row crop spacing requirement) grown in the IGP, ridge-furrow system, of 67cm width (top width of bed-37cm; and of furrow-30cm) is often considered appropriate . On the raised beds, two rows of rice, wheat, maize or chickpea are generally grown. Yields with 2 and 3 rows of wheat per bed are comparable, but lodging is greater with 3 rows per bed. It is advantageous to plant on beds a single row of pigeon pea or intercropped wheat/mustard with furrow planted sugarcane. For effective weed control, choice of crop cultivars that cover the surface early in the season is of great importance. Crop cultivars are known to vary significantly in their performance on FIRB. Efforts are in progress to identify appropriate cultivars in rice, wheat and other crops which are better suited for raised bed planting system.

Precautions for FIRB Planting in Unfavorable and Marginal Environments

Alkali soils having high exchangeable sodium are slowly permeable. These soils need o be amended with gysum, iron-pyrite and or other acid formers and leached before making raised bed. Gypsum should be mixed in surface 10cm layer of alkali soils and reaction products leached for several days.



Advantages

There are several advantages associated with bed planting systems, which are as follows:

- Management of irrigation water is improved, is simpler, and more efficient. On an average it uses, 30% less water than flat bed methods and improves crop yields by more than 20%.
- FIRB planting saves 30% to 50% wheat seed compared to flat bed planting.
- Better upland crop production is possible in the wet monsoon because of better drainage.
- Fertilizer efficiency can be increased because of better placement including top dress applications.
- Wheat seed rates are lower. Plant stands are better.
- Better tillering, increased panicle/ear length and bolder grain.
- Farmers can apply N and irrigation water at grain filling stage in wheat to improve protein content without lodging. Reduced lodging can have a significant, positive effect on yield as many farmers do not irrigate after heading precisely to avoid lodging. As a result, water can become a limiting factor during grain filling, resulting in lower yields.
- Bed planting facilitates irrigation before sowing and thus provides an opportunity for weed control prior to planting. If pre-sowing irrigation is likely to delay planting, bed planted crops can be irrigated immediately after seeding.
- Weeds between the beds can be controlled mechanically, early in the crop cycle.
- Herbicide dependence is reduced, and hand weeding and rouging between rows are easier. The major weed species affecting wheat, *Phalaris minor*, is less prolific on dry tops of raised beds than on the wetter soil found in conventional flat bed planting. Raised beds make it easier to apply herbicides because the beds allow the person spraying to follow the line. They also make possible mechanical weeding, and easier rouging or hand weeding.

Benefits of Bed Planting Observed in India

Crops	Yield on beds (t/ha)	Yield on flat (t/ha)	Water savings (% over flat)	Yield increase (% over flat)
Maize	3.27	2.38	35.5	37.4
Urd bean	1.83	1.37	26.9	33.6
Mungbean	1.62	1.33	27.9	21.8
Green peas	11.91	10.40	32.4	14.5
Wheat	5.12	4.81	26.3	6.4
Rice	5.62	5.29	42.0	6.2
Okra	34.4	29.1	33.3	18.2
Carrot	36.3	28.6	31.8	26.9
Radish	34.7	26.7	29.4	30.0
Cabbage	33.0	27.8	26.8	18.7
Pigeonpea	2.2	1.5	30.0	46.7
Gram	1.85	1.58	27.3	17.1
Cauliflower	25.9	18.9	36.4	37.0
Average	**—**	**—**	**31.2**	**24.2**

- On raised beds, border effects allows the canopy to intercepts more solar radiation, it strengthens the straws, and the soil around the base of the plant is drier to prevent crop from lodging.
- In hand harvested rice fields, wheat crop can be planted in just one pass. The bed planter reshapes the beds and furrows, plants the crop and places fertilizer at appropriate depth into the soils along seed or between seed rows in the center of the bed at 5-10cm depth. In combine harvested rice fields, crop straws can be incorporated into the beds using a shovel type furrow openers fixed on the front bar of the bed planter frame. In the absence of appropriate machinery, farmers partially burn the rice straws before seeding of wheat.
- Yield potential is enhanced through improved nutrient-water interactions and less lodging.
- Yield of rice transplanted on FIRB is comparable with traditional rice culture with as much as 25%-50% saving in irrigation water.
- Compaction of soil is limited only to the furrows used as tramlines (tractor tracks).

Conservation Tillage with Raised Beds

Research into permanent bed systems started at CIMMYT, Mexico, is showing encouraging results. An additional advantage of bed planting becomes apparent when beds are “permanent”, that is, when they are maintained over the medium term and not broken down for every crop. Making of permanent beds can help overcome constraints of resource depletion and pollution of existing systems. This has the potential of reducing cost of rice-wheat cultivation by 20%-25% over conventional methods. In this system, wheat is harvested and straw is left or burnt. The beds are reshaped by passing a shovel down the furrows. The next crop (soybean, maize, sunflower, cotton, etc.) can then be planted into the stubble in the same bed. The advantages of this system are reduced costs, erosion control, reduced soil compaction and, perhaps, better soil physical structure over time.

Zero-tillage, stubble management and reduction of herbicide use are some of the possibilities that would maintain soil structure and organic matter content while reducing air and water pollution. With permanent FIRB, crop diversification and the ability to rapidly change crop choice, for example from rice to soybean or vegetables, is possible in response to market opportunities.

After harvest, most farmers burn the crop residues and destroy the raised beds by tillage before forming new beds afresh for planting the next crop. They also apply 75% of the nitrogen fertilizers during tillage operations before planting. A long-term experiment, established in 1992 in northwestern Mexico, compared this practice with "permanent" raised beds that were formed for the first crop and only superficially reshaped before planting subsequent crops. Fourteen crops, including seven spring wheat (planted in winter) two soybean and five summer maize crops had been raised on the plots by 1998-99.

Residue Retention

Residue retention in the field had a significant beneficial effect on wheat and maize yields even under rainfed conditions of Alliplano (16-24^{0}N 1500-3000 MasL): Mexico with both Zero-till as well as with conventional tilage practices on flat beds.

Table 1. Comparison of Tillage/Seeding System and Residue Management on Wheat and Maize Yield

Tillage/seeding system	Residue management	Wheat yield (kg/ha at 12% H_2o)	Maize Yield (kg/ha at 12% H_2o)
Zero-till direct seeding	Full retention	5099	4361
Zero-till direct seeding	Full removal for fodder	3581	3574
Conventional tillage	Full retention	4435	3955
Conventional tillage	Full removal for todder	4098	3702
Mean		4303	3898
SED (35 df)		415	403

Sayre, K.D., M. Mezzalama and M. Martinez. 2001. Tillage, Crop Rotation and Crop-Residue Management: Effect on Maize and Wheat Production for Rainfed Conditions in Altiplano of Central Mexico. CIMMYT, Mexico.

Over the first five years, small but significant wheat yield differences were observed between the treatments. Major differences appeared in the wheat crop from the sixth year. Significant yield differences were also seen with various nitrogen management practices due to interaction between tillage/residue and nitrogen management. The differences in yields between permanent beds and conventional tillage were dramatic in treatments where no fertilizer was applied. More stable, and higher, wheat yields were obtained when permanent beds (FIRB) were used, all crop residues were retained and nitrogen application was delayed until the first node stage of the wheat crop. This yield advantage seems to be associated with gradual improvement in soil physical, chemical and biological parameters where tillage is reduced and crop residues retained. These results indicate that the retention of crop residues may be critical to ensuring long-term sustainability of bed planting.

Adapted from:

Connor, D.J. , J. Timsina and E. Humphreys. 2002. Prospects for Permanent Beds for Rice–Wheat Systems. *In:* Ladha, J.K. *et al.,* (eds). Improving the Productivity and Sustainability of Rice-Wheat Systems: Issues and Impacts. Special Publication, ASA. Madison, Wisconsin, USA.

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Sayre, K.D. 2001. Bed Planting Systems: An Overview. CIMMYT. Mexico (Poster).

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