FEW IMPORTANT SOIL MANAGEMENT TECHNOLOGIES FOR SUSTAINABLE CROP PRODUCTION - A REVIEW

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ABSTRACT

In irrigated farming, although intensive agriculture has brought sustainable enhancement in production of food grains but it has threatened the environment safety and promoted the degradation and inefficient use of basic resources such as land, water and fertilizer. Ridge furrow and bed-furrow systems have emerged as few of the most promising sustainable crop management technologies which increased input use efficiency and crop production without environmental degradation. Ridge-furrow system was found suitable for enhancing the production of crops sensitive to water logging, for improving the productivity of poorly drained vertisols, for checking the runoff and soil loss in erodible lands (1-3%) and for increasing the soil depth of shallow Alfisols. Besides, use of ridge-furrow system resulted in reduced water and chemical use. However, under ridge-furrow system mechanical sowing of closely spaced crops like wheat, gram and soybean and weed removal at advanced stage were big problems. Hence Broad bed and furrow system (BBF) was developed for deep black cotton soils in medium rainfall regions where mechanical sowing by seed drill could be done. In medium to high rainfall regions of Vertisols, 6-15 m wide and 30 cm high beds alternating with 6 m wide sunken beds (Raised bed-Sunken bed system-RBSB) were found most appropriate for raising both upland and low land crops. Whereas in low rainfall regions of Vertisols, 1-2 m wide raised beds were recommended for improving the crop production. Both BBF and RBSB technologies worked well in Vertisols only, where lateral movement of water was appreciable. However, they were found unsuitable for medium and coarse textured soils of Indo-Gangetic plains where vertical movement predominate over horizontal movement. Research trial on use of bed planting system (also known as furrow irrigated reduced tillage bed planting-FIRBS) for growing soybean, wheat, maize and cotton in Yaqui valley of central Mexico and Indo-Gangetic plains of south Asia showed promising results in terms of increased input use efficiency and crop productivity.

Rainfed farming in semiarid tract is a risky enterprise. Fluctuations in timing of onset of monsoon, erratic rain distribution during the crop season, sudden occurrence of high intensity rain storms and absence of in-situ water harvesting systems are major constraints in crop production in these areas. Although the amount and timings of precipitation received by crop cannot be altered but proper management of its utilization can improve crop yields.

In irrigated farming, planting on flat lands and flood irrigation are commonly used practices. Main problems associated with such practices include higher input use (such as irrigation water, fertilizer, manpower etc.), declining water table because of over exploitation of ground water resources for irrigation, greater downward movement of water fertilizer and pesticide below root zone, higher pest incidence and poor control of weeds and diseases. Thus in irrigated farming also, although intensive agriculture has brought substantial enhancement in production of food grains but it has threatened the environment safety and promoted the degradation and inefficient use of basic resources such as land, water and fertilizer. Hence there is a need to manage both rain and irrigation water efficiently by adopting appropriate soil management technology.

Ridge-furrow, broad bed-furrow, raised bed-sunken bed and furrow irrigated reduced tillage bed planting systems have emerged as few of the most promising sustainable technologies which not only increased inputs use efficiencies but also ensured sustainable crop production for meeting future demands.
without environment degradation.

**Ridge and Furrow System**

Ridge and furrow technology was initially adopted to enhance the productivity of crops sensitive to water logging like maize soybean and potato. Besides, it was also used to improve the productivity of poorly drained Vertisols. In Maharashtra for Vertisols under low rainfall (<750mm) ridges were constructed across the slope between 0.4-2%. Studies at Parbhani center of AICRP(T)(Gupta et al., 1984) showed lower bulk density, higher infiltration rate, lower moisture content of upper 50 cm, reduced water use and higher grain yields of kharif moong and rabi sorghum under ridge-furrow system than under flat planting system. Later on its use was extended for runoff control and soil and water conservation purposes in erodible lands (1-3% slope) under semi arid regions (Tejwani, 1981; Singh et al., 1993). Furrow diking (also known as furrow blocking and tied ridging) increased surface detention storage, prevented runoff (Clark, 1983; Gerard et al., 1983; Jones and Stewart, 1990), increased infiltration and thus conserved more rain water in the field. This practice in turn reduced irrigation water requirement (Allen and Musick, 1994) and yield of summer row crop (Gerard et al., 1984). For shallow red soils, ridge technology was found to be beneficial as formation of 20 cm high ridge increased soil depth and improved soil moisture stored and provided more volume of soil for root growth and increased yield of jowar, bhendi and Castor by 10-33% under rainfed condition in farmers’ field trials at Hyberabad center of AICRP(T) (Gupta et al. 1995; Das et al., 1997). In addition to increased soil erosion control, ridge tillage was found to offer benefits of reduced water and chemical inputs while maintaining same level of productivity as in conventional tillage system in different soils e.g. Alfisols, Vertisols and Inceptisols. Ridge tillage not only affected soil hydrothermal regimes but also affected soil water and solute movement. Research studies (Hamlett et al., 1990; Clay et al., 1994; Barger et al., 1999) showed that water infiltrated in furrow primarily moved laterally to row position minimising the downward solute leaching and deep percolation losses. Benjamin et al. (1997) suggested placement of fertilizer in ridges than in furrows as it would decrease fertilizer leaching and keep fertilizer within root zone. In studies by Tsegaye et al. (1993) on water saving by use of alternate and every furrow irrigation for sorghum crop by Aujla et al. (1992) on cotton, Bharmabe et al. (1999) on safflower and Graterol et al. (1999) on soybean showed 20-50% water saving without significant reduction in crop yields.

**Broad bed-Furrow Technology**

Under ridge-furrow system for closely spaced crops like wheat, gram, mustard etc., sowing (using seed drill) and removal of weeds were big problem. Hence, research activities were initiated in semi arid tropics (ICRISAT, 1984-1989; Krantz, 1981; Pathak et al., 1985; Karle, 1997) to develop broad bed and furrow system (BBF) (100-150 cm wide and 20 cm high beds and 45-50 cm wide furrows) so that sowing on the beds can be done with seed drill. Two, three or four rows of crop can be grown on broad beds and bed geometry can be varied to suit the cultivation and planting equipment. In India the system has been used mainly in deep vertisols (heavy black cotton soils) where wide beds are formed by ox drawn wheel tool carriers. The tool carriers not only used for initial forming of beds but also for subsequent annual reshaping, planting and inter row cultivation.

Main advantages of Broad bed-Furrow system included
1. Encouraging moisture storage in profile
2. Safely disposing off surplus runoff without causing soil erosion
3. Providing a better drained and more easily cultivated soil in beds.
The technique worked best on deep black soils in areas with dependable rainfall averaging 750 mm or more. It has not been productive in areas of less dependable rainfall or on Alfisols or shallower Vertisols, although in later cases more productivity is achieved than with traditional farming methods (Ryan et al., 1979).

The research revealed (ICRISAT, 1989; Patra et al., 1996; Ingole et al., 1998) that BBF system (on lands with slope less than 2%) in comparison to flat bed system induced good root development, good nodulation, better crop growth, better pod filling and early maturity in groundnut, besides considerable saving of time and cost of cultivation cost of cultivation. Research trial at Parbhani center of AICRP (Karle et al., 1997) revealed that on beds under BBF system, infiltration rate was higher, bulk density was lower and yields of rabi sorghum and kharif moong were more than those under flat planting.

**Raised bed and Sunken bed technology**

Black soils which occupy large areas in semiarid tropics are difficult to manage when wet or dry. Scientists in past developed Raised bed technology to improve water infiltration, reduce surface drainage and soil erosion. The scientific results were excellent but its adoption by farmers was slow because it was introduced in areas where water logging was not the main constraint, required expensive tillage equipment and involved higher input costs (Bantilan and Joshi, 1998). Hence new researches were conducted to modify the width of bed and furrow and no of rows to be taken per bed in order to meet their local land requirement.

In medium to high rainfall regions of vertisols (more than 1000 mm of rainfall) 6-15m wide 30 cm high raised beds alternating with 6m wide sunken beds (RBSB system) were found most appropriate for raising soyabean, blackgram, sesamum and pigeon pea on raised beds and paddy on sunken beds in kharif followed by gram, linseed and safflower on raised beds and wheat on sunken beds in rabi.

At Jabalpur (Vertisol with rainfall >800mm), in the farmers' field trials of raised bed technology it was observed that soybean grain yield on 6m wide beds increased significantly by 80% over the yield of 10.13 q/ha and paddy yield by 60% over the yield of 9.16 q/ha in sunken beds. During winter season, the rainfed gram grain yield on beds was not significantly affected but rainfed wheat grain yield increased significantly by 80% over the yield of 6.88 q/ha (Table 1). Economics of raised bed-sunken bed showed a cost-benefit ratio of 0.60 (Gupta et al., 1995).

In areas of medium and low rainfall and also in low lying and poorly drained areas (such as valley bottom) of vertisols in semi arid tract, the sizes of raised beds were reduced to 2-4m in width and 20cm in height (Karle et al., 1997). Urd, soybean on raised beds and paddy on sunken beds in kharif followed by sorghum on raised beds and safflower in sunken bed in rabi showed significant increase in yields over those under flat sowing (Table 2).

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**Table 1. Effect of construction of raised beds-Sunken beds for the management of rainfed black clay soils on crop yields at farmers’ field trials at Jabalpur (rainfall>800mm)**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Kharif crops grain yield (q/ha)</th>
<th>Rabi crops grain yield (q/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Soybean (Guarav)</td>
<td>Paddy (Purva)</td>
</tr>
<tr>
<td>Raised beds (9m)</td>
<td>18.46</td>
<td>-</td>
</tr>
<tr>
<td>Sunken beds (6m)</td>
<td>-</td>
<td>14.66</td>
</tr>
<tr>
<td>Farmer’s practice</td>
<td>10.13</td>
<td>9.16</td>
</tr>
<tr>
<td>C.D. at 5%</td>
<td>1.65</td>
<td>1.83</td>
</tr>
</tbody>
</table>
Table 2. Effect of construction of raised beds-Sunken beds on crop grain yields black clay soil at Parbhani (rainfall<800mm)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Kharif crops grain yields (q/ha)</th>
<th>Rabi sorghum yield (q/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mung</td>
<td>Urd (T-9)</td>
</tr>
<tr>
<td>Raised beds (1m)</td>
<td>15.2</td>
<td>15.8</td>
</tr>
<tr>
<td>Sunken beds (1m)</td>
<td>7.6</td>
<td>8.4</td>
</tr>
<tr>
<td>Farmer’s practice</td>
<td>10.8</td>
<td>6.8</td>
</tr>
<tr>
<td>C.D. at 5%</td>
<td>1.65</td>
<td>4.6</td>
</tr>
</tbody>
</table>

This technology after modifications is being adopted in farmer’s fields. A study in Maharashtra showed that rate of adoption of this technology has increased from 4% in 1989 to 35.5% in 1994 (Fig. 1) (Bantilan and Joshi, 1998).

![Fig. 1. Adoption of technology on raised beds in Maharashtra state, India](image)

Both RBSB and BBF technologies worked well in vertisols only, where lateral movement of water was appreciable. However, they were found unsuitable for medium and coarse texture soils of Indogangetic plains, where vertical movement predominated over horizontal movement.

**Furrow Irrigated reduced tillage bed planting system**

Research trials in early 90’s at CIMMYT, Mexico showed that crops like wheat, cotton, soybean and maize could be grown on 65-90 wide beds in alluvial plains. This technology was well adopted by small scale wheat growers in Yaqui valley of Sonara state of NW Mexico (Sayre, 1999 and Agustin, 2000) and thus has emerged as one of the promising sustainable crop management technologies. Studies by Fisher *et al.* (1995) at Glead Thorpe showed that growing two rows of potato per beds resulted in significant yield increase and water use efficiency over control.

Recent preliminary research studies at P.A.U., Ludhiana and Indian Agricultural Research Institute, New Delhi (Semi-arid region) showed that crops like wheat, maize and soyabean can be grown on beds (Aggarwal *et al.*, 1998; Aggarwal *et al.*, 2000 and Hobbs, 2001). In this mechanized system initially both bed making and sowing are done in a single operation, hence fuel and labor requirements are reduced drastically. Again for the next season sowing is done on same beds (by opening small furrows for seed placement like...
in minimum or zero tillage), which are renovated simultaneously. This further saved fuel and man power requirement. There is additional saving on herbicide use as the system has provision of mechanized weeding up to 45 DAS. Furrows along with small earthen checks at suitable intervals detains run-off water in the field and acts as an effective in-situ moisture conservation during kharrif in semi-arid regions. Again in high rainfall regions this FIRBS system has the advantage of draining excess water around the plant. This in turn provides adequate aeration, pore space for proper germination, seedling emergence and root growth. In rabi season also bed-furrow system reduces irrigation requirements as water is applied in furrows only instead of irrigating the whole of the field. Bed planter also has fertilizer-drill attachment to place fertilizer in rows near plants, which increases FUE and thus reduces fertilizer requirement as compared to conventional broadcasting of fertilizer. More field accessibility under FIRBS system for post-sowing intercultural operations along with fertilizer application at different crop stages makes it superior to conventional system (Sayre, 1997 and Agustin, 2000).

Farmers' field trials on bed planting of wheat at Pantnagar, Karnal and P.A.U. revealed that for varieties like PBW-226 and HD-2329 yields were significantly higher on beds than on flat (Hobbs, 2001). Major constraints to higher yield in North-West India are weeds and lodging. Both can be reduced in bed-planting system. Chauhan et al. (1998) showed that FIRBS system of wheat cultivation provided reasonable control of Phalaris minor weed besides improving yield of wheat with less input use.

REFERENCES


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