Wheat Cultivation Through Resource Conservation Planting Techniques

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Rice (*Oryza sativa* L.)–wheat (*Triticum aestivum* L. emend Fiori & Paol.) cropping system is a prime system occupies about 18 M ha in Asia, of which 13.5 M ha are in Indo-Gangetic Plains (IGP). In addition, a sizeable rice–wheat system area (1.06 M ha) exists in Kymore Plateau and Satpura hills agro-climatic zone of Madhya Pradesh outside the Indian IGP. Wheat is the most traded crop of the world and, next to rice as a vital source of calories, has higher protein content than other major cereals. In the last century, wheat production was revolutionized in the world with the introduction of dwarfing gene 'Norin 10' identified by Dr. Gonziro Inazuka from Norin Experiment Station, Japan and Dr. Norman E. Borlaug incorporated in wheat. In India, a noteworthy increase in productivity of wheat has been achieved during Green Revolution Era due to introduction of high yielding short statured varieties, increased use of chemical fertilizers, better irrigation facilities, improved weed and pest management measures, etc. After the green revolution era, the total factor productivity is declining and farmers have to apply more inputs to acquire the same yield. These may be due to conventional agriculture practices which involve intensive mining of natural resources and continuous degradation of natural resources. Other key reason for low wheat productivity is late planting. Many farmers grow late-maturing, fine-grained basmati rice varieties and the long turnaround time often reflects burning of previous crop residues, traditional crop establishment method, too wet or too dry soil moisture problems and unavailability of mechanical power for ploughing at the sowing time, causing late planting of wheat. There is an average yield loss 1.7% per day, when sown beyond 25 November due to high temperature above 30^{o}C at grain filling stage which influence final grain weight by reducing the duration of grain filling, due to the restraint of photosynthesis process and by inhibition of starch synthesis in the endosperm. This prompted to adopt alternative resource conservation planting techniques for wheat, which could enhance yield, conserve natural resources and minimize environmental pollution.

What are Alternative Resource Conservation Planting Techniques for Wheat?

Zero-till drill, rotary till drill, minimum tillage and bed planting come under the alternative resource conservation techniques for wheat planting which are very useful for conserving natural resources, reducing environmental pollution and improving productivity.

Cultivation Practices

Field preparation and sowing

Zero-Till Drill: Zero-till drill is the direct placement of seed and fertilizers into an untilled seedbed by the help of a specially-designed machine. Research on zero tillage (ZT) for wheat in India started almost three decades ago with the following key events:

1970: Start of zero tillage research but lack of suitable planting machineries and weed management problem.

1991: First prototype of the Indian ZT seed drill developed by GBPUA&T, Pantnagar.

1997: Improved ZT drill by private manufacturer.

Early 20th Century: Happy Seeder developed by the Dept. of Farm Power and Machinery of Punjab Agricultural University, Ludhiana.

Where combine harvesting is being popular, rice crop should be harvest from 12-15 cm height from the surface, crop residue should not burn and spot application of glyphosate on green weeds. Before the sowing, crop residue spread uniformly over the field. 'Happy Seeder' machine can drill wheat in the presence of crop residue under zero-till condition (Fig. 1). Seeder should be clean and calibrate prior to sowing. In manually rice harvested field, there is no previous crop residue so simple zero-till machine like Pantnagar zero-till ferti-seed drill can be used for direct drilling of wheat.

Figure 1. Sowing of Wheat by "Happy Seeder"

Rotary Till Drill: The combination of rotary tiller with seed-cum-fertilizer drill and a light planker allows soil preparation with placement of seed and fertilizers and planking the soil in single operation (Fig. 2).

Figure 2. Sowing of Wheat by Rotory Till Drill

In manually-harvested rice field, direct drilling of wheat crop along with fertilizer placement and planking the field in single pass can be done by rotary till drill. But in combine harvested rice field, the machine can be used after removal of loose rice straw. Straw baler machine can be used for straw removal from field instead straw burning. Straw burning is an environmental enemy process. Farmers can trade rice straw and make money. The rice straw can be utilized by paper industry for paper production, dairy industry for fodder, mashroom industry for mashroom production, packaging industry for goods packaging, sugar industry for electricity and for organic manure production.

Minimum Till Drill: In conventional practice, there are 6 to 10 tractor operations to prepare the seed bed but in minimum till drill, there is minimum soil manipulation necessary for successful crop production. Tractor operations can be reduced from 6 to 10 to 2 to 3 operations.

There is minimum soil disturbance which is necessary for successful crop production. In manually-harvested rice field, one pass of cultivator followed by one pass of rotavator is sufficient to pulverized soil for successful crop production. In combine- harvested rice field, loose rice residue is incorporated by one pass of grass cuter machine followed by one pass of cultivator and rotavator, respectively are satisfactory to pulverized seedbed.

Bed Planting: In this technology, after land preparation all three activities viz. bed formation, placement of fertilizers and seed are done in single pass.

In manually-harvested rice field, land preparation is done by one pass of cultivator followed by one pass of rotavator. In combine-harvested rice field, loose rice residue is incorporated by one pass of grass cuter machine followed by one pass of cultivator and rotavator, respectively are sufficient for land preparation. After achieving the well till seedbed,

bed planter is done all three activities viz. bed formation, placement of fertilizers and seed in single pass (Fig. 3).

Figure 3. Sowing of wheat crop by raised bed planter

Seed Rate and Seed Treatment

Seed rate of wheat is 80-100 kg/ha under resource conservation practices. In case of bed planting, seed rate may be reduced to 75 kg/ha. To protect the crop from seed- and soil-borne diseases, it is essential to treat the seed with fungicides *viz.* vitavax 75 wp @ 2.5 g/kg, Carbendazim (Bavistin 50 wp) @ 2.5 g/kg or tebuconazole (Raxil 2 DS) @ 2.5 g/kg seed.

Weed Management

The critical period of crop-weed competition is 30-45 days after sowing. Weeds compete with wheat for nutrients, soil moisture, sunlight and space when they are limiting, resulting in reduced yield, lower grain quality and increased production costs. Upto 30% mean loss in wheat yield by uncontrolled weeds and remove 20-90 kg nitrogen/ha, 2-13 kg phosphorus/ha and 28-54 kg potassium/ha from soil. A mixed flora of broad-leaved, grasses and cyperaceous weeds grows with wheat under different agro-climatic conditions. The most common weed species are given in Table 1.

Table 1. Common weed flora of wheat crop

Grassy weeds	**Cyperaceous**	**Broadleaf**
Phalaris minor (little canary grass), *Avena fatua* (wild oats), *Cynodon dactylon* (Bermuda grass), *Polypogon monospliensis* (foxtail), *Poa annua* (annual meadow grass),	*Cyprus rotundus* (purple nutsedge), *Cyprus esculentus* (yellow nutsedge)	*Chenopodium album* (lamb's quarters), *Rumex retroflex* and *R. dentatus* (golden dock), *Convolvulus arvensis* (field bind), *Melilotus indica* (sweet clover), *Melilotus alba* (white clover), *Medicago hispida* (Toothed bur clover), *Vicia sativa* (wild vetch), *Portulaca oleracea* (Pigweed), *Anagallis arvensis* (red chickweed)

Hand-weeding with a *khurpi* at 20-25 days after sowing is a conventional approach to manage weeds. Due to increasing nuclear families, expensive and shortage of farm labour, this approach is now restricted to small and marginal farmers. Also it is difficult to identify *Phalaris minor* and *Avena fatua* in early stage of growth from wheat seedlings. Chemical approach is effective and affordable for weed management. A pre-emergence of pendimethalin in 400-500 litres/ha of water within 3 days after sowing (DAS) provides a broad-spectrum control of weeds in wheat. However, post-emergence application of Mesosulfuron methyl 3% + iodosulfuron methyl Sodium 0.6% or Clodinafop-propargyl + Metsulfuron or Sulphosulfuron 75% WG + Metsulfuron 5% WG etc. is necessary for effective control of weeds at 20-25 DAS.

There is poor efficacy of pre-emergence herbicide in zero tillage with rice residue retention due to presence of straw on surface results less contact between herbicide and land surface however, increased water volumes up to 600 to 800 liters/ha or application of pre-emergence herbicide just before a light irrigation through sprinkler which is necessary for uniform germination might be increase efficacy.

The adoption of zero tillage for wheat planting is emerging as a novel tool in weed management. Zero-till technology is an effective tool for managing *P. minor*, possibly due to early sowing in October as *P. minor* germinates at a temperature of 17-18^{0}C, which usually prevails in the middle of November and 6-8 t/ha of rice straw as a mulch reduces emergence of *P. minor* and other weeds.

Fertilizer Management

The general $N+P_2O_5+K_2O$ (kg/ha) recommendations for wheat are 120+60+40, respectively in Madhya Pradesh. Half dose of nitrogen should be applied as basal and remaining half dose should be top-dressed at first irrigation. But in zero tillage with rice residue retention, 70% of nitrogen should be drill by happy seeder along with seed at different depth and remaining 30% of nitrogen should be top-dressed at flowering stage. Higher basal dose of nitrogen should be applied in zero tillage with rice residue retention due to broadcasting nitrogen onto the residue-covered surface is an inefficient method of top-dressing because there is less contact between nitrogenous fertilizer and land surface due to residue and potential for immobilization by surface residues and volatilization losses of nitrogen.

Water Management

Wheat requires about 300-400 cm of irrigation water, depending upon various factor *viz.* climatic, edaphic and nature of variety. Water should be applied at critical stages for potential yield production. A light irrigation through sprinkler should be applied after the sowing for uniform germination. Crown-root initiation (21 DAS), late tillering (42 DAS), late jointing (60 DAS), flowering (80 DAS), milk (95 DAS) and dough (115 DAS) are the six critical stages for irrigation. The number of irrigation to be given on the basis of availability of water is given in Table 2.

Table 2. Number of irrigations based on the availability of water

No. of irrigation available	Critical stages
1	Crown-root initiation
2	Crown-root initiation + Late jointing
3	Crown-root initiation + Late jointing + Milk
4	Crown-root initiation + Late tillering + Flowering + Milk
5	Crown-root initiation + Late tillering + Late jointing + Flowering + Milk
6	All six critical stages

Remaining practices like plant protection, harvesting and threshing operations are similar to conventional planting of wheat. Need based plant protection may be taken up.

Some Facts About Resource Conservation Techniques for Planting

Residue Burning: In conventional agriculture, residue burning is a common practice for taking up *rabi* crop wheat where combine harvesting is being popular. However it is destructive in respect to environment, soil health and crop productivity. Burning practices of crop residues in rice-wheat rotation system adopted by farmers of Punjab and Haryana cause severe smog in the months of October-November in Delhi. News cited in "The Hindu" news paper of November 12, 2014 published a report that NASA's Aqua and Terra satellites witnessed hundreds of agricultural fires in farmers' field near to Delhi on November 6, 2014 and stated that such fires peaking in a span of merely two days and the smoke from it travelling towards Delhi. A popular Indian news channel 'Aaj Tak' broadcasted the news on November 4, 2015 that National Green Tribunal (NGT) ordered to four north Indian states including Delhi to issue the notification regarding crop residue burning in rice-wheat cropping system. NGT said that farmers will be fined (Rs. 5000-1500) if they will burn crop residue in the field. Burning of crop residue emits green houses gases (Table 3), losses of nutrients (Table 4), decrease the efficacy of several herbicides due to increased adsorption of carbon content (ash) and also reduce the beneficial microbial activities in soil as well. Resource conservation practices for wheat planting would be a better answer to this question.

Table 3. Effect of burning of rice and wheat crops residues on methane and nitrous oxide emissions in India and Madhya Pradesh for the year 2010–11

Crop type	CH_4 emitted (Gg carbon equivalent)	N_2O emitted (Gg carbon equivalent)	Total emissions (Gg carbon equivalent)
India			
Rice	1.17	0.46	1.62
Wheat	7.63	1.19	8.82
Total	8.8	1.65	10.44
Madhya Pradesh			
Rice	82.37	32.44	114.81
Wheat	73.32	11.42	84.74
Total	155.69	43.86	199.55

Table 4. Rice residue on a dry-weight basis contents N, P, K, S and Ca (kg/tonne)

N	**P**	**K**	**S**	**Ca**
5-8	0.7-1.2	15-25	0.5-1	3-4

Energy use: Conventional planting consumes more energy, time and fuel (Table 5) than conservation planting techniques. Per liter of diesel burnt produces around 2.5 kg CO_2.

Table 5. Conservation planting techniques compared to Conventional planting practice

Particulars	**Zero tillage**		**Bed planting**	**Conventional planting**
	Zero till drill	**Happy Seeder**		
Time (h/ha)	3	4	13	11
Fuel used (l/ha)	12	18	55	44
Operational energy (MJ/ha)	687	1029	3173	2542
CO_2 equivalent (kg/ha)	30	45	140	115

Source: *Kheti*, June 2014.

Rodents: Farmers often complain regarding rodent problem in zero-till fields due to heavy load of crop residues which provide shelter in the field and thus encourages rat growth. Zinc phosphide is the most commonly used rotenticide bait for the management of rodents.

Tractor: Machinery for resource conservation techniques like happy seeder needs 45-50 HP tractors but maximum farmers having the tractors of 35 HP. So it is a major constraint to adopt resource conservation techniques.

Trust Area

There is problem of perennial weeds specially Cynodon dactylon which is not manage by the selective as well as non-selective herbicides in zero-till farming. In zero-till farming, there is need to quantify the dose of fertilizers in initial transition period of 2-3 years and after the 3-4 years of zero-till farming as well because crop residue use as mulch on soil surface which increases soil organic carbon and soil organic carbon is the store house of nutrients. There is scope to develop light weight machinery for resource conservation techniques which will not require high HP tractors. There is need to aware the farmers about the payoffs of resource conservation techniques by ‘On Farm Trial’.