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Strip Tillage Seeding Technique: A Better Option for Utilizing Residual Soil Moisture under Rainfed Moisture Stress Environments of North-West Bangladesh

Md. Israil Hossain[1], M. K. Gathala[2] and T.P. Tiwari[2]
[1]Principal Scientific Officer (Agric. Engg.), Regional Wheat Research Centre, BARI, Shyampur, Rajshahi, Bangladesh (E-mail: mdisrail@gmail.com); [2]Cropping Systems Agronomist, CIMMYT Bangladesh

Abstract

Strip tillage seeding system technique is a conservation agriculture based resource conserving technology, which employs tilling the soil in strip just in front of furrow opener and place seed, and fertilizer in line at right depth in a single operation just after aman rice harvest to utilize the residual soil moisture for crop establishment. especially in rainfed moisture stress areas. The rotating strip blades can operate through moderate anchored previous crop residues without plugging and dragging with furrow openers. The seeder creates 4-6 cm wide planting strip and produce good tilth for better seed and soil contact which facilities better plant germination. A multi-location experiment was conducted to evaluate the performance of strip tillage for wheat, lentil and mungbean during 2008-2011 in Rajshahi district, Bangladesh. The higher soil moisture (16.4 %) was maintained at 35 days after seeding under strip tillage than full tillage treatments (13.4 %). The effective field capacity was 27 % higher with strip tillage than minimum tillage (Power Tiller Operated Seeder). The total time requirement for field preparation and planting was highest in conventional tillage (17.5 hr/ha), intermediate in minimum tillage (6.7 hr/ha) and lowest in strip tillage (5.26 hr/ha). The fuel consumption during seeding operation was 57 % and 38 % lower than conventional and minimum tillage, respectively. The strip tillage achieved higher grain yield (wheat 4.96t/ha, lentil 1.4t/ha, mungbean 1.5 t/ha) in all three crops with a net saving in cost of sowing BDT 3050/- ha^{-1} than conventional tillage. In this study, we found that the break-even point of strip tillage seeder was 4.0 ha in a year for service providers.

Key words: *Strip tillage, minimum tillage, conservation agriculture, break-even point*

Introduction

Agricultural machinery plays an important role to reduce drudgery of farm works, turnaround time and production cost. The current methods of land preparation and sowing operations are very exhaustive, expensive and time-consuming for crop production. Right amount of seeds and fertilizers and right placement are necessary for good germination and crop establishment thereby better crop yields [1]. Strip till planting system in which tilling the planting strips and accomplished seed and fertilizer placement simultaneously in a single operation, thereby reducing the number of field operations which is environment friendly because of low fuel consumption and less soil disturbance. In this system land is remain untilled between the two seeding lines. No till facilitates improvement of soil quality, reducing the surface soil erosion and keep residue over the soil surface which reduces soil moisture losses [2, 3].

Farmers of Bangladesh are becoming more dependent on mechanical power. Now a days two wheel tractor operated power tillers are available all over the country. There are about 700,000 two wheel tractors (2WT) in operation [4]. Survey showed that the use of 2WT in wheat planting is gradually increasing for example, 11%, 17% and 55% in 1991, 1992, and 1994, respectively [5, 6]. The turn-around time between T. Aman (Monsoon) rice harvest and wheat seeding is very narrow only 15-20 days. After harvesting of T. Aman, farmers do not have enough time for land preparation with current conventional tillage practices that results in delayed wheat planting and high risk of soil moisture losses. Delay in planting is one of the main constraints in wheat production. Generally after harvesting T. aman, 10-22 days are required for field preparation under conventional tillage, which includes 4-5 ploughings followed by 3-4 times laddering. Power tiller operated seeder (PTOS) performs tillage operation, seeding in line and seed covering simultaneously. During last few years, performance of strip tillage seeder was demonstrated at different locations of North-West Bangladesh. In the strip tillage system crop residue remains on the soil surface, which helps to preserve soil moisture and also have smothering effect that partly reduces weed infestation, especially in rainfed moisture stress environments.

The objectives of the study were,

(i) To establish crop under strip tillage seeding system utilization of residual soil moisture;
(ii) To demonstrate and evaluate strip tillage performances for different crops under rainfed moisture stress areas, and
(iii) To compare the cost of planting between strip tillage seeder and the conventional methods.

Materials and Methods

Power tiller operated seeder (PTOS) has 48 numbers of rotating blades for pulverizing soil at shallow depth with very high speed rotating blades. The seeding part is attached with power tiller replacing the rotavator part of the power tiller. In strip till system, rotating blades were reduced to 24 numbers. Only 4 blades in face to face configuration remain in the gang at front position of seed furrow opener for tilling in 4-6 cm strip and creating tilt soil just in front of furrow openers and between the two furrow openers the soil remained untilled. The "J" type blades of the seeder rotates at the speed of 450 rpm. Simultaneously, the seed and fertilizer placement was done in a single operation. (Fig.1). The experiments were conducted in Chargat, Durgapur, and Puthia area of Rajshahi district during 2008-2011. Wheat, and lentil were planted after the harvest of T. aman rice and mungbean was planted immediately after wheat harvest using residual soil moisture. Rice was harvested at 20 cm height to keep around 30% anchored residue.. Recommended fertilizer was used and placed during seeding operation. Each block was separated into three parts for the three methods of tillage: (i) Strip tillage (ii) minimum tillage by PTOS, that means full shallow tillage in one pass and (iii) conventional tillage broadcasted method. During the study the following observations/ data were collected (i) Seeding depth/placement (cm), (ii) Implement travel speed (km/hr), (iii) Effective field capacity (ha/hr), (iv) Field efficiency (%), (v) Fuel consumption (l/hr), (vi) No. of plant/m^2, (viii) Soil moisture (%), (ix) Yield(t/ha) (x) Tillage cost BDT.

Fig.1. Strip till seed drill

Results and Discussion

Three years results clearly showed that the retention of soil moisture was longer under strip tillage system as compared to conventional and minimum tillage (Fig 2). The maximum soil moisture content (16.4 %) at 0-15 cm soil depth was observed at 35 days after seeding under strip tillage techniques followed by (14.2 %) with minimum tillage (PTOS) and conventional tillage methods (13.24). The higher soil moisture content under strip tillage could be due to less soil disturbance, and residue management that might have reduced surface evaporation than that of minimum and conventional tillage.

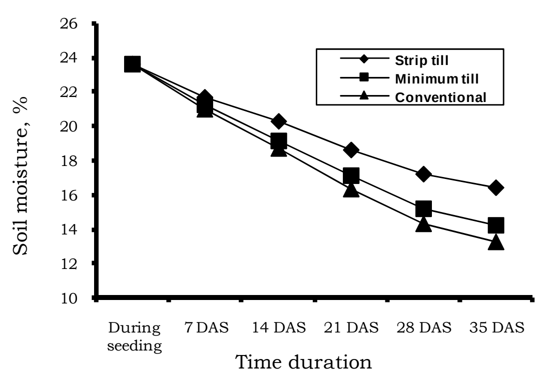

Fig. 2: Soil moisture variation after seeding

Performance of strip tillage, minimum tillage by power tiller operated seeder (PTOS) and conventional tillage is shown in the Table 1. The effective field capacity of the seeder in strip tillage method was higher (0.19 ha/hr) than minimum tillage (0.15 ha/hr). In strip tillage method, seeder moved (19%) faster than minimum tillage seeder (PTOS). The higher effective field capacity and speed under strip tillage system might be because of work load variation due to less tillage area with half number of blades, their configuration and alignment that resulted in less slippage losses and more surface area coverage. The fuel consumption measurement was also made under different tillage systems during planting and field preparation. In strip tillage seeding, 57% and 38 % lower fuel consumption were recorded than conventional tillage and minimum tillage seeding, respectively. The lower fuel consumption under strip tillage (5.8 l/ha) was due to, partial soil tillage, and less power requirement by reducing the number of tilling blades.

Table 1: Comparative performance of different tillage methods

Sl. No.	Parameter	Strip tillage	Minimum tillage	Conventional
1	Travel speed (km/hr)	2.5	2.1	-
2	Effective working width, cm	120	120	-
3	Effective field capacity (ha/hr)	0.19	0.15	-
4	Drive wheel slippage (%)	6	8	-
5	Fuel consumption (lit./ha)	5.8	9.3	13.6
6	Total time requirement (hr/ha)	5.26	6.7	17.5

Results clearly showed that seeding operation by strip tillage method were completed in 5.26 hrs for one hectare land compare to 6.7 hr and 17.5 hr of minimum tillage and conventional broadcasted method, respectively. The seeding operation through strip tillage saved 69% time compare to conventional tillage and broadcasted method.

Fig.3: Strip till wheat field

In strip tillage and minimum tillage (PTOS), seeding depth was maintained at 3-4 cm and it could be adjusted as per crop type and soil moisture level but in conventional tillage broadcast system, there is no mechanism available to maintain the seeding depth and it can be varied from 0-8cm depending on tillage depth and type of tillage implements used for mixing the seed. In new seeding techniques, strip tillage and minimum tillage seed rates was 120 kg/ha compared to 155 kg/ha under conventional tillage broadcasted system. In conventional broadcasted method 20 % higher seed rate were used than recommended rate to mitigate improper seed germination risk because of improper seed placement. The placement of seed and fertilizer at right depth and amount resulted better crop establishment in different crops under strip tillage and minimum tillage compared to conventional system (Table 2). The higher plant population of wheat (286/m^2), and lentil (195/m^2)under strip tillage than conventional system (wheat=255 /m^2, and lentil=180/m^2) might be due to better soil to seed contact, less soil moisture depletion after seeding and better seed and fertilizer placement at right depth. There was no difference for mungbean was quite surprising (Table 2).

Table 2. Comparative performance of strip tillage, minimum tillage and conventional tillage method in 2011

Parameter	Strip tillage			Minimum tillage			Conventional method		
	Wheat	Lentil	Mung	Wheat	Lentil	Mung	Wheat	Lentil	Mung
Seed rate (kg/ha)	120	25	20	120	25	20	155	35	30
Seeding depth (cm)	4-5	3-4	4-5	3-4	3-4	3-4	0-8	0-6	0-6
Width of strip (cm)	4-6	4-6	4-6	-	-	-	-	-	-
Plant population/m^2	286	195	30	275	205	28	255	180	23-35

In general, higher yields were observed under strip tillage than minimum and conventional tillage system (Table 3). Strip tillage seeding system produced significantly higher grain yields for all three crops i.e. wheat (4.96 t/ha), lentil (1.40 t/ha) and mungbean (1.50 t/ha) than conventional tillage seeding system i.e. wheat (3.56 t/ha), lentil (1.20 t/ha), and mungbean (1.00 t/ha), respectively. There was no difference between minimum tillage and conventional tillage methods in wheat yield, however, this was not the case for lentil and mungbean, where minimum tillage found to be better than conventional tillage statistically. The higher crop yields under strip tillage and minimum tillage could be due to better crop establishment, uniform crop stand, and higher fertilizer efficiency through band placement of fertilizer than conventional tillage system. The more additive crop yield gain under strip tillage might be cumulative effect of partial surface residue retention and better soil moisture content than minimum tillage.

Table 3: Yield performance of strip tillage over minimum tillage and conventional method

Method	Crop yield (t/ha)		
	Wheat	Lentil	Mungbean
Strip tillage	4.96	1.4	1.5
Minimum tillage	4.80	1.2	1.0
Conventional	3.50	0.8	0.75
SE	0.5	0.3	0.6
(CV%)	12	14	11

The cost of planting in different seeding methods was shown in Table 4. Among the three planting methods the cost of strip tillage system was minimum (Tk.1850./ha) and the highest was in conventional method (Tk.4900). In both modern techniques (strip and minimum) 62 % planting cost were saved over conventional tillage (broadcasted seeding system). The major saving under strip tillage was achieved due to drastic reduction in tillage operations, less labor, seed and fuel cost.

Table 4: Cost of planting in different tillage methods

Sl. No.	Planting methods	Cost of planting (Tk./ha)
1	Strip tillage	1850.0
2	Minimum tillage	1873.0
3	Conventional method	4900.0
SE		247
CV (%)		13

1 US$=Tk.80.0

Beak-even point of crops for strip tillage drill is shown in Fig. 4. Break-even point is calculated on the basis of fixed cost and variable cost of strip seed drill considering purchase price, interest on investment, machine life, etc. [7]. Cost per hectare decreased with the increase of land area used annually. Breakeven point of strip tillage was found 4.0 ha which indicated that it is the point where no loss or no profit occurs. The owner of the strip seed drill must plan for profit, therefore they are suggested to cover much more than 4.0 ha land per seeder on annual basis.

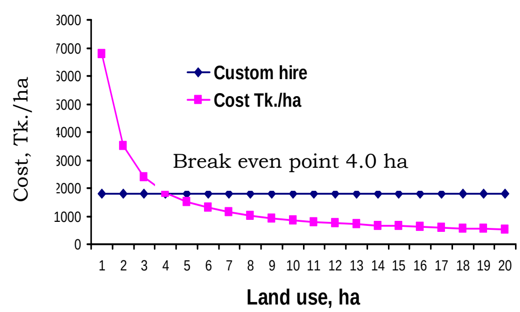

Fig.4: Break-even use of strip till drill

Conclusion

This study evaluated a set of conservation agriculture based resource conserving tillage techniques to address how to use residual soil moisture in rain-fed areas, higher cost of production and low productivity due to late planting in northwestern Bangladesh. Based on the multi-locations trial results, the following opinions and conclusions were made.

i) Strip till can be replaced to existing conventional system for higher crop productivity with reduced cost of production. This is equally important with respect to soil health.

ii) Residual soil moisture can be utilized through strip tillage technique by advancing the seeding of wheat and lentil after T. Aman harvest.

iii) It can be reduced the fuel consumption up to 57 % (good for environment) and reduce turnaround time for field preparation.

iv) This technology could be promoted to other parts of Bangladesh where bio-physical and socio-economic environments are similar.

v) The further research to be needed to quantify the total net returns, effect on soil health on long run.

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