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

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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 (PTOS). 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 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**

I. INTRODUCTION

Agricultural machinery play an important role to reduce drudgery of farm works as well as minimize operational time and production cost. The current methods of land preparation and sowing operations are very expensive and time-consuming for crop production. Proper placement, right amount and distribution of seeds and fertilizers into the soil are necessary for good germination and crop establishment for better crop yields [1]. Strip till planting system in which tilling the planting strips and accomplished seed and fertilizer simultaneously in a single operation, thereby reducing the number of field operations which is environment friendly because of low fuel consumption and less soil erosion. 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 350000 two wheel tractors in operation [4]. Survey results showed that 11%, 17% and 55% of wheat growers used power tillers for cultivating wheat 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 and its resulted delayed wheat planting and high risk of soil moisture losses. Delay in planting is one of the main constraints to increasing wheat yields; generally 10-22 days are required for field preparation under conventional tillage. This conventional tillage includes 4-5 passes ploughing 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. Strip tillage system crop residue on the soil surface helps to preserve moisture and resist growing weeds especially in rainfed moisture stress environment.

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 cultivation in rainfed moisture stress areas and
(iii) To compare the cost of planting by strip tillage seeder than that of the conventional methods.

Fig.1. Strip till seed drill

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II. 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 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 strip 4-6 cm 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 were rotating at the speed of 450 rpm. Simultaneously, the seed and fertilizer placement was done in a single operation. (Fig.1). The experiment was conducted in Chargat, Durgapur, Puthia area of Rajshahi district during 2008-2011. Wheat, lentil planted after T. aman rice harvest plots and mungbean planted immediate after wheat harvest using residual soil moisture. The average height of the rice residue was 15-20 cm. 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.

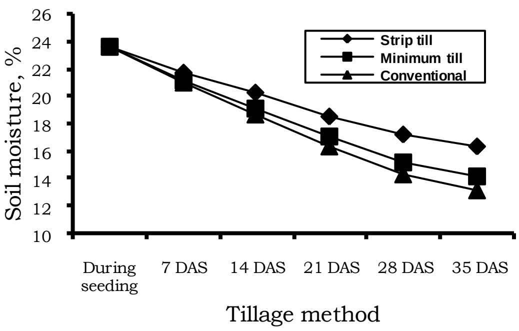

Fig. 2: Soil moisture variation after seeding

III. RESULTS AND DISCUSSION

The 3 year results clearly showed that soil moisture maintain for longer period after seeding under strip tillage system compared to conventional and minimum tillage (Fig 2). The maximum soil moisture content (16.4 %) at 0-15 cm soil depth were observed at 35 days after seeding under strip tillage techniques followed by (14.2 %) with minimum tillage (PTOS) than conventional tillage methods (13.24). The higher soil moisture content under strip tillage could be due to less soil disturbance, minimum expose with air and sun for evaporation and partially soil surface covered by crop residues than minimum and conventional tillage. Performance of strip tillage, minimum tillage by power tiller operated seeder (PTOS) and conventional tillage were shown in the Table 1. The effective field capacity of the seeder in strip tillage method was higher (0.19 ha/hr) than minimum till seeding (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 less tillage area with half number of blades and their configuration and alignment, less slippage losses and more surface area coverage. The fuel consumption measurements were 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 less number of tillage passes, partially soil tillage, and less power requirement by reducing the number of tilling blades.

Fig.3: Strip till wheat field

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TABLE I

WORKING PERFORMANCE OF STRIP TILL AND MINIMUM TILL SEED DRILL

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

The 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 save 69% time compare to conventional tillage and broadcasted method.

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 traditional method 20 % higher seed rate were used than recommended due to improper seed germination because of improper seed depth. The placement of seed and fertilizer at right place 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 286, 195 and 30 was recorded for wheat, lentil and mungbean under strip tillage, respectively than conventional system and it might be due to better soil to seed contact, less soil moisture depletion after seeding and better seed and fertilizer placement at right depth.

TABLE II

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

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In general, higher crops yield trend 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 for all three crops i.e. wheat (3.56 t/ha), lentil (1.20 t/ha), and mungbean (1.00 t/ha), respectively. In minimum tillage the crop yields are at par for wheat and lentil but significantly lower yield for mungbean than strip tillage system. The crop yields were significantly differs among minimum tillage and conventional till system. 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 III

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 IV

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 profitable use of seeder over 4.0 ha land yearly.

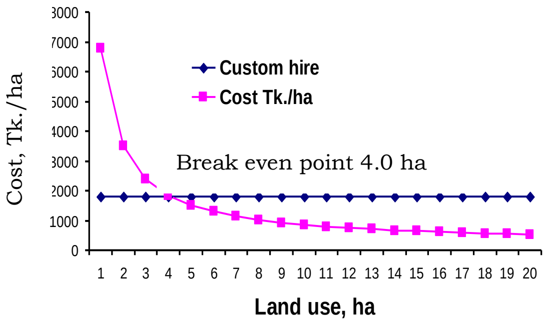

Fig.4: Break-even use of strip till drill

IV. 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 with higher crop productivity and reduce cost of planting.

ii) Residual soil moisture can be utilize 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 % and reduce turnaround time for field preparation.

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

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