Two-Wheel Tractor Operated Zero Till Seed Drill: A Viable Crop Establishment and Resource Conservation Option

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Written for presentation at the
2004 CIGR International Conference · Beijing
Sponsored by CIGR, CSAM and CSAE
Beijing, China
11- 14 October 2004

Abstract. *A simple two-wheel tractor (Chinese Dongfeng type) operated zero till seed and fertilizer drill attachment has been developed jointly by the Wheat Research Centre of the Bangladesh Agricultural Research Institute (BARI) and the International Maize and Wheat Improvement Center (CIMMYT) Without prior land preparation, this machine places seed and fertilizer directly into the soil in one operation. There is tremendous scope for such tools for conserving agriculture attachments as there are over 200,000 Chinese two-wheel tractors currently in Bangladesh. This prototype version of the zero till seed drill is made up of four major components, namely, a toolbar frame, a furrow opener, a seed delivery unit and a fertilizer delivery unit. The performance of the machine has been tested in 180 farmers' fields in different parts of Bangladesh for wheat and maize in 1999-2004. The crop yields are similar compared to the conventional methods. The effective field capacity of the machine was found to be 0.18 ha per hr for simultaneous seeding and fertilizer application. Planting cost of wheat and maize were 83% and 89% less than that of conventional method. The two-wheel tractor*

operated zero till seed drill, thus, has a good potential as a resource conserving crop establishment technology for the Bangladeshi farmers.

Keywords. Power tiller, zero till seed and fertilizer drill, two-wheel tractors, resource conserving crop establishment technology.

Introduction

Agriculture of Bangladesh for crop establishment is mostly being done by the two-wheel tractor with full tillage. Farmers applied four to six ploughs and two laddering for seed bed preparation. This is the common practice of land preparation. This traditional way of land preparation for crop establishment is laborious, time consuming and costly. The existing full tillage system for wheat establishment after rice is delayed by 10-15 days (Saunder 1998). The optimum wheat planting season begins from November 15 and ends November 30. Because of the full tillage system practice, 50 – 60% farmers delayed their wheat planting. Delay wheat planting results 1.33% yield loss per day (Sanders 1988). Zero till saves planting time, fuel, water, improves efficiency of fertilizers, reduce weed density, reduces the wear and tear of tractors, improve soil health, promotes residue management and helps reduce air pollution (Hobbs and Mehla, 2003). Furthermore, it could increase farmers profit by US$ 55-75 per ha (Gupta, et al. 2003). To overcome the problem and help the farmer to establish crops on time, with the less cost, zero tillage or no till, planting seed with minimum soil disturbance is one of the best alternative options.

Because of the benefits, about 107,000 farmers of South Asia have adopted zero tillage in 0.6 million ha of land. The yield of zero tillage fields are more in areas where late planting is a common practices as compared to timely sown areas (Gupta et al, 2003).

The exponential use of Chinese two-wheel hand tractors are the main farm power source for land preparation, irrigation, threshing, winnowing, transport of the commodities from farm to nearest market place in Bangladesh. Survey reveals that the use of two-wheel tractor in Bangladesh was 11% in 1991 and which has increased to 17% in 1992, 55% in 1995 and 75% in 2003 (Saunders, 1990, 1991; Meisner, 1992, 1996, 1999, 2001 and 2003) which has got tremendous potential for its use in different crop establishment and agricultural operation through the development of new accessories.

Therefore, the USAID funded “Facilitation and Promotion for Adoption of Mechanization by Growers” program has been undertaken to develop the two wheel tractor zero till seed and fertilizer drill for meeting the challenges of reducing production cost, conserving resource, eliminating delay planting and ensuring sustainable food production. The objectives of the program are to:

- construct a toolbar frame of two-wheel tractor zero tillage drill machine;
- make seeding and basal fertilizer application device and fixing it with the toolbar frame;
- test the machine performance with wheat and maize establishment;
- promote the technology.

Materials and Method

The two-wheel tractor zero tillage drill was fabricated with locally available materials such as M.S. angle, solid bar, M.S sheet, ball bearing etc. The main functional parts of the drill was toolbar frame, seed and fertilizer metering device, seed and fertilizer box, furrow opener (inverted "T" opener), depth control wheel and chain with sprocket for power transmission from two-wheel tractor's axel wheel (Figure 1). Field tests were conducted at different locations of Bangladesh from 1999 to 2002 in the farmers' field. The performance evaluation of the zero till drill also has been done through several farmers' fields monitoring. The necessary improvement

has been done on the basis of feed back from farmers, operators, manufacturers and crop field observation. The testing of the drill was done by attaching it to a 12-16 Hp Dongfeng two-wheel tractor being manufactured by China. The wheat variety was Protiva and Di Ammonium Phosphate (DAP) fertilizer was used as basal for wheat cultivation. The planting depth and seed covering mechanism were adjusted during the field operation. The machine performance parameters were recorded as per Regional Network of Agricultural Machinery (RNAM) Test code. Field data were also collected to determine the labour requirement and cost of sowing by conventional method.

In 2003, the zero till drill was demonstrated for wheat planting in 180 farmers' field of Bangladesh.

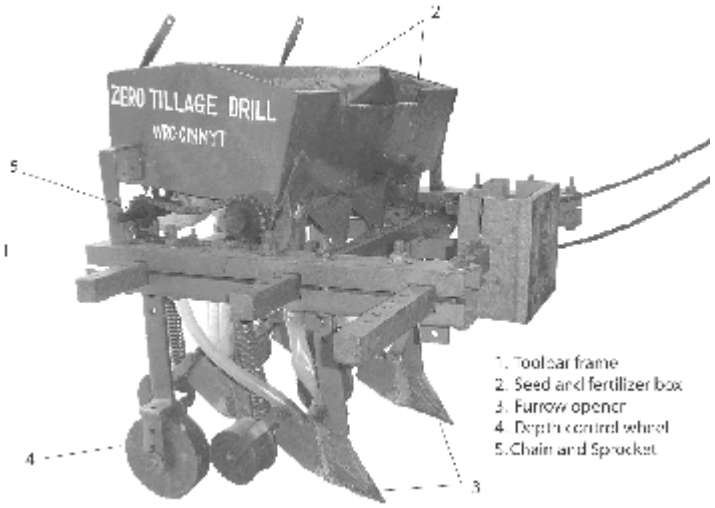

Figure 1: The two-wheel tractor operated zero till drill with main functional components

Data collection

A. The following agronomic data were collected during field test:

- depth of seeding (cm)
- crop stand establish (per m^2)
- grain yield (t/ha)

B. Following engineering data and collection methods are described below:

Seed calibration

Transparent polythene bags were tagged with each of the four seed delivery tubes. The zero till planter was operated on a pre-measured 20 m travel distance with a sowing width of 80 cm, thus providing a 16 m^2 area. After every 20 m linear distance run, collected seeds through tubes were weighed separately and the total seed weight was also noted. This method was repeated

by acceleration and deceleration of the lever of seed meter until the desired seed rate obtained. Since the seed metering device is connected by a chain -sprocket arrangement to the power tiller wheel axel, the speed of the tiller should not be a factor in calibration, unless there is wheel slippage. The seed rate was determined through calculation by using the following equation (Michael and Ojah, 1978).

$$Sd = 10\ Ws/Am$$

Where, Sd = Seed rate (Kg/ha)

Ws = total wt. of seed (gm) Am= measured experimental area, m^2

Turning loss

It is the time loss during turning of the power tiller at the end of every pass. The loss time was recorded by the stop watch.

Wheel slippage

It is the travel reduction of the tiller during operation in the field. Generally expressed by percentage.

$$S = \frac{n1 - n2}{n1} x100$$

Where, S = Wheel slippage, %

n1= Ten revolution distance in concrete floor, cm

n2= Ten revolution distance in the field, cm

Speed of operation

Pre-measured distance was fixed by two standing sticks. During the time of sowing, fixed distance passing time was recorded by stopwatch and travel speed was computed using the following simple relation.

$$S = 3.6\ d/t$$

where, S = travel speed (km/hr)

d = pre-measured distance, m (20 m)

t = recorded time (s)

Theoretical field capacity

Theoretical field capacity was calculated as

$$TFC = \frac{WxS}{10}$$

Where , TFC = theoretical field capacity (ha/hr)

W= width of the seeder (m)

S= travel speed (km/hr)

Effective field capacity

It is the actual field coverage of the seeder per unit time. Effective field capacity was calculated as follows.

EFC = A/T

Where, EFC = effective field capacity (ha/hr)

A= total area sown by the machine (ha)

T = Total recorded time (hr)

Field efficiency

It is the percentage of effective field capacity and theoretical field capacity.

Fe = x 100

Where, Fe = Field efficiency (%)

Fuel consumption

The fuel tank was filled and re-filled before and after the sowing operation, respectively. Re-filled quantity was the fuel consumption.

Fc = Fr/t

Where, Fc = fuel consumption (l/hr)

Fr = re-filled quantity of fuel (l)

t = seeding time (hr)

C. Economic of zero till age and conventional tillage

- Following data were recorded for economic analysis:
- Fuel and oil consumption (litter per hour)
- labour hours
- Depreciation cost of machine (Anonymous, 1991)
- Seeding and fertilizer application time

Results and Discussion

On the basis of collected data and field observation since 1999, results are described as follows:

Zero till drill field performance

Table 1 shows the efficiency parameters of zero till drill of wheat and maize from the demonstration trial. It has been observed during the trial that performance efficiency of the zero till drill differed between wheat and maize. Fuel consumption, wheel slippages effective field capacity and field efficiency were found higher in wheat than maize. However, only speed of operation for maize was higher than wheat. It was also found that slower speed was comparatively better for seed placement in the opening slit.

Table 1: Efficiency performance parameters of zero till drill in wheat and maize crops establishment

Sl No	Parameters	Wheat	Maize
1	Fuel consumption, lit./hr	1.40	1.25
2	Speed of operation, km/hr	2.20	2.25
3	Wheel slippage,%	17	14
4	Effective field capacity, ha/hr	0.18	0.16
5	Field efficiency, %	83	80

Seed and fertilizer application

In untilled land, the two-wheel power tiller operated zero till drill could apply seed and fertilizer in one pass. The seed and fertilizer were applied in 3-4 cm depth in the same slit. The applied seed rates of wheat and maize were 120 and 20 kg per ha respectively (Table 2). Flute type gravity flow seed metering devices was used for both wheat and maize sowing. The wheat seed rate was 40% less compared to the conventional method, but the maize seed rate was the same as conventional. Results also indicated that about 7-8% gap filling and about 10% thinning were needed for maize due to the missing seed dropping for uneven seed size. The dose of basal fertilizer (Di Ammonium Phosphate) rates for wheat and maize was 180 and 230 kg per ha, respectively. Plant population of wheat was 20% higher compared to the conventional methods. During field monitoring, it was observed that the less (80%) cutworm attack was occurred in the zero till maize field compared to the conventional method.

Table 2: Crop performance of power tiller operated zero till drill

Sl No	Parameter	Wheat	Maize
1	Seed rate, kg/ha	120	20
2	Row to row spacing, cm	20	70
3	Depth of planting, cm	3-4	4-5
4	Width of opening slit, cm	1-2	1.2-2.4
5	Number of plant/m2	215	7

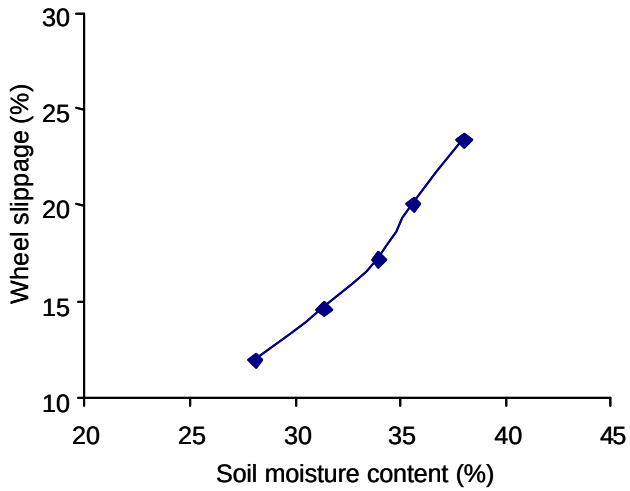

Figure 2: Relationship between soil moisture and wheel slippage

Soil moisture content vs. wheel slippage relationship

Soil moisture content is an important factor for efficient operation of the zero till drill. The zero till drill was tested in a wide range of soil moisture content to determine optimum moisture content for efficient operation of the machine. The best moisture content for the operation zero till drill was found below 35% of soil moisture content. However, the soil moisture content above this value decreased the machine operation efficiency due to higher percentage of wheel slippage (Figure 2).

The two wheel tractor zero till and fertilizer drill have been demonstrated in different farmers' fields. The yield of wheat and maize in zero tillage system and conventional method were compared (Table 3). The yield of wheat in zero till method varied place to place due to variation in land type, soil moisture, lack of fertilizer doses application and weed management. The average wheat yield was found 3.5 t/ha and was comparable to conventional method. It was also observed from intensive field monitoring that the sandy loam soil produce lower yield (2.8 ton/ha) than heavy clay soil (4.5 ton/ha) in some demonstrated area. The yield of maize in zero till was 1.4 ton/ha less than conventional till method.

Table 3: Comparison of yield between zero tillage and conventional method

Sl No	Planting system	Yield (t/ha)	
		Wheat	Maize
1	Zero tillage system	3.5	8.1
2	Conventional method	3.1	9.5

Maize and wheat planting cost

The planting cost including land preparation of wheat and maize in zero tillage planter were 83% and 89% less compared to the conventional method (Table 4).

Table 4: Comparison of cost of planting by zero tillage and conventional system

Sl No.	Planting method	Planting cost (Tk./ha)	
		Wheat	Maize
1	Zero till	233.0	262.0
2	Conventional till	1250.0	2388.0

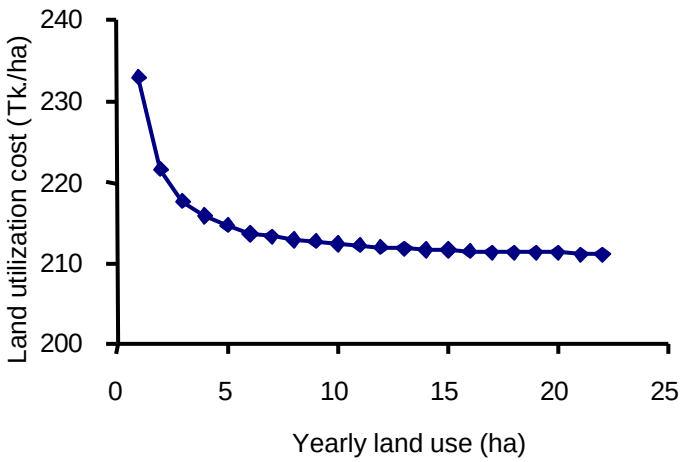

Figure 3: of annual land use by two-wheel tractor zero till drill

The economic land utilization of the machine was also determined. It was found from the study that for no loss and no profit this zero tillage has to be operated in at least 8 ha per year (Figure 3). For making valid conclusion about the machine profitability in terms of land utilization coverage, the study has to be repeated for more than one year.

Technology Promotion

To create awareness about the benefit of the zero tillage as resource conservation technologies of CIMMYT, the Wheat Research Center with FAO funding up-scaling the technologies in five different wheat growing locations at Dinajpur, Jessore, Rajshahi, Noyakhali and Jalampur in 2003/04. This program is considered as an additive program of CIMMYT-WRC ongoing research and development program of agricultural machineries. The technologies have been demonstrated in 180 farmers' fields. The average wheat yield of two-wheel tractor zero till drill and conventional fields were 3.09 and 3.51 ton per ha, respectively. It could be mentioned here that farmer could not able to plant wheat in optimum time due previous long duration rice crop, lack of weed management, sandy loam field selection, and poor fertilizer management. Though the wheat yield was 12% lower than conventional, but the planting cost of zero till method was 83% less than conventional.

Conclusions

The following conclusions could be drawn from this study:

1. The Chinese two-wheel tractor is an appropriate power source for operating the zero till and fertilizer drill accessories.
2. Using this two wheel operated zero till drill for wheat and maize planting could save 83% and 89%, respectively.
3. The accessories could be used for placing the seed and fertilizer at a time at right soil moisture zone.
4. Turn-around time between harvesting of monsoon rice and planting of wheat could be reduced by 10-15 days compared to conventional. Due to time saving, wheat yield increased by 1.33% per day.
5. To use the two wheel power tiller operated zero till drill, much weedy field and sandy loam soil should not be selected.

Acknowledgements

The authors greatly acknowledge the support of Dr. Larry Harrington, Director, Intensive Agroecosystems Program, CIMMYT for inviting and presenting the papers in the conference. The authors are greatly indebted to Dr. Nur E Elahi, CIMMYT Affiliate Scientist (Maize) for his contribution for improving the manuscript. We greatly acknowledge the support of CIMMYT-Bangladesh colleagues for the preparation of the manuscript. Finally, the authors express sincere gratitude to the USAID for funding this program.

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