Versatile multi-crop planter for two-wheel tractors: an innovative option for smallholders

Haque ME[1], Bell RW[2], Islam AKMS[3], Sayre K[1], Hossain MM[4]
[1] International Maize and Wheat Improvement Centre (CIMMYT), Bangladesh and Mexico; enamul.haque71@gmail.com
[2] School of Environmental Science, Murdoch University, Murdoch, WA 6150 Australia
[3] Bangladesh Rice Research Institute, Gazipur, Bangladesh
[4] Department of Farm Power Machinery, Bangladesh Agricultural University, Mymensingh

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Introduction

The rapid spread of mechanisation on small farms in Asia has not yet led to the development of a range of low-cost planters for two-wheel tractors (2-WT) that can be used for minimum tillage (Baker et al., 2002). Such planters are needed to develop conservation agriculture (CA) practices on small farms, and in diverse cropping systems they need to be capable of operating in multiple planting modes and with a wide range of crops. The initial 2-WT based developments with zero tillage (ZT); single-pass shallow (up to 60 mm deep) full tillage (SPST), strip tillage (ST) and bed planting (BP) in Bangladesh were reported by Haque et al. (2004 and 2010) and Roy et al. (2009). Despite these promising developments, none of the present planters for 2-WT are capable of planting in all modes of tillage. The aim was to develop a planter that could be used in ZT; SPST; and conventional tillage (CT) with 4 to 8 tillage and 3 to 4 laddering operations by 2-WTs; and to shape permanent beds, when driven by 12-16 HP 2-WTs. A key aim of the development was for a planter on which setting up of blades, row spacing, seed depth and the calibration of seed and fertiliser rates could be accomplished quickly by the operator in the field. Incorporating features from a range of earlier planters for 2-WTs, a Versatile Multi-crop Planter (VMP) was designed with capability for seed and fertilizer application in lines.

Materials and Methods

The VMP was designed with capability for seeding with fluted roller or vertical plate seed and fertilizer meters in line planting for SPST, ST, ZT, BP, and for CT using full rotary tillage. The VMP was powered by a Chinese Dongfeng or Saifeng 12 HP 2-WT. The net weight of VMP is 152 kg and its overall dimensions are length 990 mm, width 1220 mm, and height 840 mm (Figure 1). The VMP is mounted on a 700 mm toolbar attached through side arms and connecting rods to the main handle of the 2-WT. This allows for seeding and fertilizing in four adjustable lines if row spacing is 200 mm and down to a single row in the case of maize sown in 600 mm beds. There is capacity for up to 32 blades attached by 8 brackets to a square shaft. Brackets are made to clamp onto the square shaft by two bolts. Both fluted roller and vertical plate seed meters can be fitted depending on the level of precision in seed placement required. The fertilizer box similar in design to the seed box and is fitted with four fluted meters with four flutes each for delivery fertilizers. Furrow openers are made from 2 mm steel sheet bent to 180 degrees with a round leading edge to help stubble clearance and attached on the toolbar by two U-clamps. A pressing roller is attached behind the furrow openers by a pair of arms. Bed shaping capability is added by bolting to each side of the pressing roller truncated cone set with a flat bar frame. By contrast with the standard rotary tiller that has blades bolted at fixed positions; the VMP has adjustable blade positioning. This was achieved by replacing the round shaft with a square shaft and then

designing brackets that can slide across the shaft while holding two or four blades. The sliding of the bracket sideways without blade removal enables row spacing to be adjusted quickly in the field according the crop requirements. Hence the square shaft and brackets designed for the VMP achieve improved flexibility for multi-crop planting on a field-by-field basis. Data on seed and fertilizer rates calibration were determined using the equation of Michael and Ojah (1978). Data on wheel slippage and operating speed; theoretical field capacity; effective field capacity; and fuel consumption were determined according to the methods used by Haque et al. (2004). The VMP was widely evaluated in 16 districts in 1000s farmers fields for several tillage modes: up to four rows of ZT with furrow openers; ST with 16 blades attached on four brackets; SPST; two rows of crops on BP (60 cm) with 32 blades attached on eight brackets, and; CT with 16 blades attached on eight brackets. Initially a fluted roller was used to meter seeds and found to be suitable for delivering continuous seed flow, but not for evenly spaced seed in crops such as maize. However, if continuous seed dropping is preferred, the fluted rollers are satisfactory and cheaper.

Results and Discussion

Among tillage treatments, no significant difference was observed in case of chickpea emergence after seed metering using the fluted roller, however, significant improvement in plant establishment was observed with all one-pass planting methods in case of mung bean and with strip and zero tillage with black gram (Table 1).

Table 1. Established plant population (plants /m^2) using the fluted type seed meter on the Versatile Multi-crop Planter for sowing chickpea, mung bean and black gram with different tillage options in the High Barind Tract, Rajshahi, Bangladesh.

Crop	CT	SPST	ZT	ST	BP
Chickpea	56a	55a	47a	57a	31a
Mung bean	27c	145ab	121b	209a	101b
Black gram	22b	-	99a	93a	52ab

In a row, means followed by a common letter are not significantly different at 1 % level by Duncan's Multiple Range Test.

Field capacity under CT with higher speed (4^{th} gear) was significantly higher at 0.11 ha per hour (Table 2), than for SPST, ST, ZT and BP which fluctuated around 0.06 ha per hour with lower speed (1^{st} gear). Operation of the planter with lower speed for SPST, ST, ZT and BP was useful to make the row straight and allow seed and fertilizers uniform distribution. In the case of CT, the operator can ride to the 2-WT and that decreased the time losses for turning. However, for precise planting operator needs to go slower speed, turn the planter and place uniformly for make the straight row planting that increases the time losses. The SPST, ST, ZT and BP by VMP saved 38, 82, 50 and 13 % diesel fuel over CT (Table 2). Land prepared by VMP saved 50-68 % labour in land preparation, seeding and fertilizer application. The greatest savings were with SPST and ST, followed by ZT and BP (Table 2). The overall operational costs for SPST, ST, ZT, and BP were US$ 19.8, 10.3, 18.1 and 28.8 ha^{-1} which were 52, 75, 23, and 13 % (Table 2) lower than the CT method for chickpea, black gram and mung bean planting. The depreciation and repairs costs were not considered. To date a total of 45 units of VMP have been sold including 6 to international buyers in India and Vietnam; and eight private buyers providing services for planting crops in Bangladesh. Four VMPs service providers have been rented out the VMP to 656 farmers covered total 81 ha of wheat (32 ha in 237 farmers), maize (16 ha in 122 farmers fields), mungbean (13 ha in 101 farmers fields) and rice (11 ha in 80 farmers fields).

Table 2. Effect of tillage mode by the Versatile Multi-crop Planter on fuel consumption, field capacity, labour requirement in land preparation and seeding of chickpea, mung bean and black gram in clay soil at High Barind Tract, Rajshahi, Bangladesh (data in brackets refer to % savings relative to CT).

Tillage type	Field capacity (ha/hour)	Fuel consumption (l/ha)	Labour requirement, (person-hours/ha)	Cost of land preparation and seeding[§] (US$/ha)
CT	0.11a	33.1a	48.1a	41.5a
SPST	0.07b	20.6c (37.7)	15.4c (68.1)	19.8d (52.3)
ST	0.07b	5.83e (82.4)	15.3c (68.3)	10.3d (75.2)
ZT	0.06b	16.6d (49.8)	17.3c (64.0)	18.1c (23.4)
BP	0.05b	28.9b (12.6)	23.9b (50.5)	28.8b (12.7)
Probability (<1% level)	**	**	**	**

[§] Considering variable costs for labour and diesel fuel.

Conclusion

The VMP is a unique multi-functional and multi-crop planter powered by 12-16 hp 2-WT with capability for seed and fertilizer application in variable row spacing using single-pass shallow-tillage, strip tillage, zero tillage, bed planting, and conventional tillage. The square shaft and brackets designed for the VMP achieve improved flexibility for multi-crop planting and capacity for rapid adjustment of row spacing on a field-by-field basis. Planters such as VMP could be used to develop CA practices across a wide range of cropping systems used by smallholder farmers in Asia, Africa and other regions.

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