



WORLD
CONGRESS 7
on Conservation Agriculture

2017

Congreso
Aapresid

1 to 4 August
Rosário
Argentina

PROCEEDINGS



With technical support of



**Food and Agriculture Organization
of the United Nations**



BLADE SPECIFICATIONS FOR STRIP-TILLAGE ON EXCESSIVELY MOIST CLAY SOILS IN SOUTHERN BANGLADESH

Md Abdul Matin^{(1, 2)*}, Timothy J. Krupnik⁽¹⁾, Md Israil Hossain⁽²⁾, Mahesh K. Gathala⁽¹⁾

⁽¹⁾ International Maize & Wheat Improvement Center (CIMMYT), Gulshan 2, Dhaka 1212, Bangladesh

⁽²⁾ Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur 1701, Bangladesh

*Corresponding and presenting author, Email: m.a.matin@cgiar.org; matmy014@mymail.unisa.edu.au

ABSTRACT

Intensifying cropping on fallow lands during southern Bangladesh's dry winter season is challenged by predominantly clay soils that retain excess post-monsoon season soil moisture. Use of conventional machinery to repetitively till and manually establish crops can delay dry season sowing by days or weeks, precluding timely crop establishment and exposing crops to late-season soil salinity, terminal heat, flash floods, and other risks. Two-wheeled tractors with attachable rotavators are used for strip-tillage by removing some of the tillage blades which allows rapid single-pass strip-till furrow formation and crop establishment. Current practice of using commercially available bent or straight C blades operated at the depth of 50–60 mm however results in either excessive soil throwing (with bent blades) or an incomplete furrow (with straight blades) in the excessively moist clay soil condition. Both result in poor seed coverage, increased seed predation, reduced germination and suboptimal plant stands. This study aimed to improve seedbed furrow quality in the moist clay soils (moisture content of 28.2%, bulk density 1.44 gcm⁻¹). We tested three blade designs (conventional, medium and straight) at 50–100 mm depths in a soil bin. The blades (4 blades/row providing a cutting width of 50 mm and rotor diameter of 342 mm) were operated at 470 rpm and a forward speed of 0.4 ms⁻¹. Both blade design and operating depth significantly affected seedbed furrow depth, width, backfill (loose soil remaining in the furrow after strip-tillage), and production of optimum clods (1–20 mm) and unwanted fines (<1 mm). While none of the blades could produce enough backfill at the cutting depth of 50 mm, use of greater depths produced sufficient backfill only in case of the straight blades. Irrespective of the cutting depth, the all the blades produced a high percentage of optimum clods, but a low percentage of fines. We consequently recommend use of straight blades (slightly longer to provide a rotor diameter of 420–450 mm) and an operating depth of 75–100 mm so that the rotor or blade holders do not touch the ground or hinder residue flows.

BACKGROUND

Bangladesh is the most densely populated country in the world supporting 161 million people on a land area of 130.2 million ha (World Bank, 2015). Due to population growth, urbanization, and demand of land for other non-agricultural purposes, per capita availability of arable land has decreased to one-thirds during the last four decades. In order to continue feeding the growing population, the country has been looking for opportunities to sustainably intensify cropping in the single cropped area of the southern Bangladesh where 1.7 million farming households follow their lands after harvesting the monsoon rice (Krupnik et. al., 2017). However, cropping on these fallow lands during dry winter season is challenged by predominantly clay soils that retain excess post-monsoon season soil moisture. Use of conventional tillage machinery (e.g. rotavators) to repetitively till and dry soil and later manually broadcast seeds to establish crops can delay dry season sowing by days or even weeks, precluding timely crop establishment and exposing the crops to late-season soil salinity, terminal heat, and early monsoon season storms. Use of conservation agriculture (CA) machinery can play an important role to reduce the turnaround time and produce an additional crop.

APPLICATIONS AND IMPLICATIONS FOR CONSERVATION AGRICULTURE

Two-wheeled tractors with attachable rotary seeders are becoming increasingly popular among farmers for rapid land preparation and seeding in one or two passes of the seeders. These seeders can be converted in to strip-till drills (e.g. Haque et. al., 2010; Hossain et. al., 2009) and used for CA to reduce costs and turnaround time between crops. This conversion requires removal of 50–83% of the rotary blades to enable tilling only narrow furrows (50–60 mm wide and 50–60 mm deep) while simultaneously sowing seeds in one pass of the seeder. Thus, the strip-tillage leaves the rest of the field undisturbed and covered with crop residues and help conserve soil moisture. Use of these drills can therefore facilitate early crop establishment in relatively moist soil (>80% of field capacity) opening up the opportunity to produce an additional crop during the dry winter season while minimizing costs and increasing farmers' profit potential.

Conventionally used C type blades of the rotary seeders perform well for traditional full disturbance soil tillage. However, their use for strip-tillage tends to result in excessive soil throw out of the furrow producing inadequate furrow backfill¹ resulting in poor seed coverage, increased seed predation, reduced germination, and sub-optimal plant stands. The soil throwing occurs mainly during the exit of the blade by its sidelong section (Matin et. al., 2014). In order to reduce soil throw Matin et. al. (2015, 2016) therefore suggested an alternate blade design (straight blade) for strip-tillage that can reduce soil throw, improve furrow backfill, produce soil tilth optimum for seed germination, and also reduce energy requirement. However, preliminary field test with the straight blades in a moist clay soil of the southern Bangladesh has shown that the straight blades (at the common setting of 4 blades/row, 50–60 mm operating depth) cannot break the soil completely to create a furrow; mere create two independent slots (each 6–10 mm wide) and thus are not suitable for strip-till seeding. Since the soil carrying ability of a certain width of blade is fixed, it is expected that increase in tilling depth would produce a complete furrow while reducing soil throw, increasing backfill and improving soil tilth due to increased re-tillage². Therefore, this soil bin study tested the conventional, straight and medium (shorter sidelong section) blade designs at a range of operating depths to quantify their effect on furrow depth, width, backfill, and soil tilth and recommend a blade design and setting for strip-tillage in excessively moist clay soil condition.

¹Backfill is defined as the amount (kgm⁻¹) of loose soil (or percentage of the original soil) retained in the furrow after tillage.

²Re-tillage is tilling of the same soil more than once (by either more than blade or more than once by the same blade, or both).

EXPERIMENTAL APPROACH

To maintain accurate tillage depths and a uniform soil condition, the study was conducted using the indoor soil bin and seeding test rig facility at the Bangladesh Agricultural Research Institute, Gazipur, Bangladesh. The soil bin was filled with clay soil (47.2% sand, 22.0% silt and 30.8% clay) collected from the field. The soil was watered, spaded, mixed, levelled, and finally compacted with 50 passes of a roller to obtain a 125 mm soil bed ready for testing (1440 kgm⁻³ bulk density and 28.4% moisture content that corresponds to 85% of field capacity). A two-factor completely randomised design with three replications conducted over time with newly remoulded bins, was thus used for the experiment, with treatments being as follows.

Factor A (blade design) – 3 treatments: conventional, medium, and straight

Factor B (blade operating depth) – 3 treatments: 50 mm, 75 mm, and 100 mm

The forward travel and rotary speeds were maintained at 0.4 ms⁻¹ and 480 rpm (forward rotation), respectively using the rig. The conventional and the medium blades were 43 mm and 23 mm wide, respectively while the straight blades were 4 mm thick. The blades were set for a cutting width of 50 mm (4 blades/row as recommended by Lee et. al., 2003 and Matin et. al., 2014) and a rotor diameter of 355 mm.

Data collection process in the following three days included cleaning away the soil clods thrown outside the furrow, collecting loose soil (i.e., furrow backfill) from a 500 mm furrow section, oven drying the collected soil at 105 °C at least for 24 hours, weighing, and hand sieving through 20 mm and 1 mm sieves. Amount of furrow backfill was calculated as the weight of dried soil collected from the furrow and expressed in kgm⁻¹. Similarly, amounts of large, optimum, and fine clods were calculated as the weight of the dried soil retained on 20 mm sieve, 1 mm sieve, and pan, respectively and also expressed in kgm⁻¹. The furrow center depth and top width were also calculated as mean of readings taken at 10 consecutive locations spaced 50 mm along the furrow run using a 0.5 mm graduated ruler as described by Matin et. al. (2014). The collected data sets were statistically analyzed for variance (F-test).

RESULTS AND DISCUSSION

Analyses of variance (F-test) of furrow parameters (Tab. 1) showed that the furrow width, backfill, and amounts of optimum and fines clods were significantly affected by both the blade design and the operating depth. However, the furrow depth was not significantly affected by the blade design, but by the operating depth. The interaction effect of the blade design and operating depth was significant for all the furrow parameters except furrow width.

Table 1. Analysis of variance of furrow parameters.

Sources of variation	Degrees of freedom	F-value				
		Furrow depth, mm	Furrow width, mm	Backfill, kgm ⁻¹	Optimum clods, kgm ⁻¹	Fines, kgm ⁻¹
Blade (B)	2	2.81 ^{ns}	10.7 ^{**}	48.6 ^{**}	48.4 ^{**}	20.3 ^{**}
Depth (D)	2	238 ^{**}	7.57 ^{**}	25.2 ^{**}	21.5 ^{**}	11.2 ^{**}
B x D	4	6.03 ^{**}	1.40 ^{ns}	6.03 ^{**}	5.81 ^{**}	4.08 [*]
Error	18					

* means significantly different at $p < 0.05$; ** means significantly different at $p < 0.01$; ns means not significantly different at $p < 0.05$.

Furrow depth and width

The furrow depth increased with the blade operating depth irrespective of the blade designs (Fig. 1, left). All the blades generally tilled furrows slightly deeper than the blade operating depth (except for the straight blade at 75 mm which left uncut bottom ridge along the furrow center). At the 100 mm operating depth, the straight blade produced the deepest furrow. This indicates that the soil failure ability of the straight blade increases at a high operating depth of 100 mm which would help cut complete furrows on excessively moist clay soil condition as found in the southern Bangladesh. Due to the widest sidelong section, the conventional blade produced furrows much wider than that produced by the medium or straight blade (Fig. 1, right) similar to that was observed in previous studies conducted in a sandy loam soil condition (Matin et. al., 2014). This suggests that to obtain a 50 mm wide furrow, the cutting width of blades could be set at <50 mm (e.g. 40–45 mm) to help reduce power requirement and cost of operation.

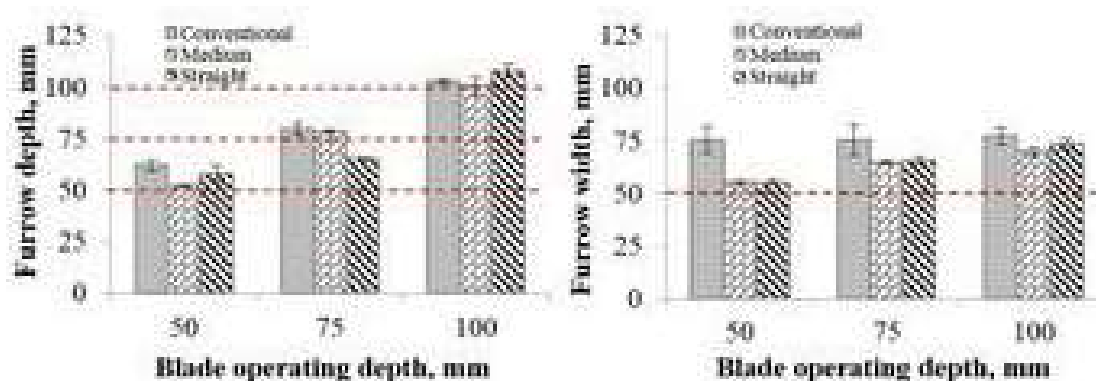


Figure 1. Effect of blade design and operating depth on furrow depth (left) and furrow width (right) (Vertical bars represent standard error of means).

Furrow backfill and soil tilth

As seen from Fig. 2 (left), irrespective of the operating depth, the straight blade produced the highest backfill which was 2–3 times of that produced by the other blades. However, visual assessment suggested that the backfill was sufficient for seed covering only in case of the straight blade at 75–100 mm depths.

Quality of the soil tilth significantly varied due to the blade design or the operating depth. All the blades produced negligible amounts (by ratio 1.1–2.5% only) of fines (Fig. 2, right). This would help reduce the chance of formation of surface crust that frequently observed after irrigating a tilled soil having high percentage of fines. The rotary and forward speeds used in this study provided a short bite length of 13 mm which helped achieve high percentages of optimum clods (65–82%) for all the treatments. Although these percentages were high for the conventional and medium blades, quantity wise they were insufficient to cover seeds (Fig. 2, right). Therefore, considering the straight blades ability to till a complete furrow of desired depth and width that contains high amounts of backfill and optimum soil clods, the study recommends the use of straight blades (slightly longer to provide a rotor diameter of 420–450 mm) and an operating depth of 75–100 mm so that the rotor shaft or blade holders do not touch the ground or rake residues.

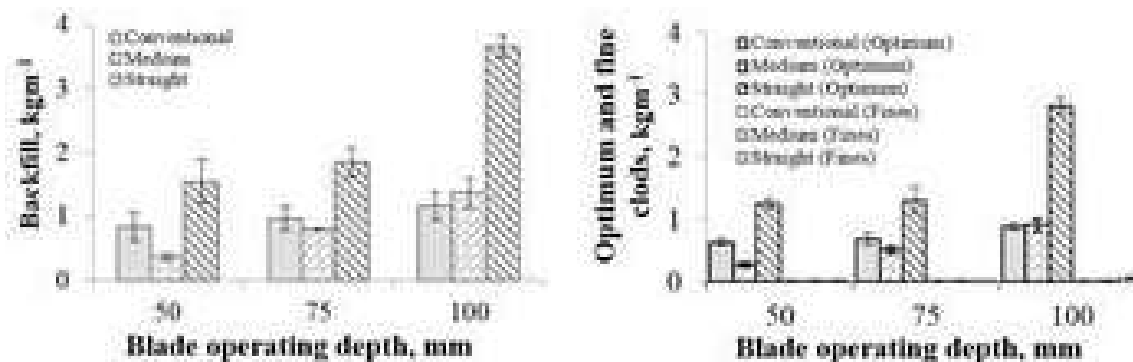


Figure 2. Effect of blade design and operating depth on furrow backfill (left), and soil tilth (right) (Vertical bars represent standard error of means)

REFERENCES

- Haque, M.E., R.J. Esdaile, E. Kabir, W. Vance, R.W. Bell, A.M. Musa, A.K.M Shahidullah, M.N.N. Mia, M. Maruffuzaman, and C. Johansen. 2010. Minimum-tillage, mechanised sowing of pulses with two-wheel tractors. *Proc. 19th World Congress of Soil Science*, 1–6 August, Brisbane, Australia, pp. 156–159.
- Hossain, M.I., R.J. Esdaile, R. Bell, C. Holland, and M.E. Haque. 2009. Actual challenges: developing low cost no-till seeding technologies for heavy residues; small scale no-till seeders for two-wheel tractors. *Proc. 4th World Congress on Conservation Agriculture*, 4–7 February, New Delhi, India, pp. 171–177.
- Krupnik, T.J., U. Schulthess, Z.U. Ahmed, and A. McDonald. 2017. Sustainable crop intensification through surface water irrigation in Bangladesh? A geospatial assessment of landscape-scale production potential. *Land Use Policy*, 60:206–222.
- Lee, K.S., S.H. Park, W.Y. Park, and C.S. Lee. 2003. Strip-tillage characteristics of rotary tiller blades for use in a dry land direct rice seeder. *Soil and Tillage Research*, 71:25–32.
- Matin, M.A., J.M. Fielke, and J.M.A. Desbiolles. 2014. Furrow parameters in rotary strip-tillage: Effect of blade geometry and rotary speed. *Biosystems Engineering*, 118:7–15.
- Matin, M.A., J.M. Fielke, and J.M.A. Desbiolles. 2015. Torque and energy characteristics for strip-tillage cultivation when cutting furrows using three designs of rotary blade. *Biosystems Engineering*, 129: 329–340.
- Matin, M.A., J.M.A. Desbiolles, and J.M. Fielke. 2016. Strip-tillage by rotating straight blades: effect of cutting edge geometry on furrow parameters. *Soil and Tillage Research*, 155:271–279.
- World Bank. 2015. Available at <http://data.worldbank.org/country/bangladesh?view=chart>, accessed on 25 June 2017.