Development of a Shoe Attachment to the Existing Furrow Opener of Tractor Drawn Seed cum Fertilizer Drill and its Performance Evaluation

Suryakanta Khandai, N.Mahapatra and M.K.Ghosal

ABSTRACT- The plain shovel type of furrow opener mostly used in the presently available seed cum fertilizer drill has been modified by attaching a suitable shoe to it with a view to solve the problem of frequent soil sticking in the seed and fertilizer tubes and also to achieve the proper placement and coverage of seed in the soil. The performance of the developed shoe attachment to the existing plain type furrow opener was evaluated in the soil bin of the Dept. of Farm Machinery and Power, OUAT, Bhubaneswar, Odisha during the year 2012. Experiments were conducted in sandy loam soil and the effects of draft requirements of three types of furrow opener like developed furrow opener prototype (Furrow 1), plain shovel (Furrow 2) and shovel with shoe attachment (Furrow 3) were studied with moisture contents within 8-9%, 11-12%, 14-15% and 17-18% (wb) for four speeds of operation (0.8 km/h, 1.2km/h, 1.6km/h and 2 km/h) and for three depths (50 mm, 60mm and 70 mm). Soil strength was maintained between 800 kPa to 1000 kPa. Similarly, the furrow parameters studied during the course of experiments were furrow bottom, soil throw and soil coverage after passage of furrow opener in the soil bin. The data collected through experiments were analyzed statistically by following completely randomized design (CRD) method. It was found that the draft requirements for the developed shoe attachment were 30-35 % more than the plane shovel but soil coverage in the developed unit was found better and was about 100 per cent higher than the plain shovel at all depths studied. The draft requirement of the developed shoe attachment was also found very much suitable for the existing tractor operated seed cum fertilizer drills equipped with shovel type furrow openers only.

Key Words: Furrow opener, Seed cum fertilizer drill, Tillage, Draft, Sandy loam soil, Soil bin

INTRODUCTION

Multiple cropping system in today's agricultural sector demands power driven machinery to achieve timeliness of farm operations. Sowing is a prime operation in the cultivation practice of any crop for correct placement of costly and critical inputs like seeds and fertilizers in the soil. It is an art of placing seeds in the soil to have good germination, seedlings emergence, crop establishment and higher grain yield in the field (Kepner et al. 1987). The performance of sowing implements is properly achieved by the suitable design of both seed metering device and furrow opener. The use of the correct type of furrow opener facilitates better seedling emergence and establishment which is due to improved depth control and seed to soil contact.

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Furrow opener is the final modifier of soil environment in the seed bed (Chuadhuri, 2001 and Damora 1995). In general, it cuts a furrow and allows seeds to be deposited before being partially covered by the soil. Its prime consideration is to give minimum soil disturbances and reduced tendency for clogging in the seed tube (Madhusudan Reddy et al. 2013 and Kumar et al. 2013). Further, the furrow opener in a seeding device is required to make furrow in the moist soil zone with minimum soil disturbance to avoid mixing of top dry soil with underlying moist soil at seed level (Magar et al. 2010). Also, past studies indicate that the factors such as depth of operation, speed of operation, moisture content of soil and furrow type have significant role on the performance of the furrow openers used in seed cum fertilizer drill (Chaudhury, 1994 and Singh, 2007). Proper covering of soil after the placement of seed in the bed is another desirable factor in the design of furrow opener for reducing soil moisture losses through lesser soil disturbance.

The seed cum fertilizer drill (tractor and bullock drawn) is at present gaining popularity in India for line and timely sowing of seeds within the available short period from the harvest of one crop to the sowing of the next crop (Shrivastava and

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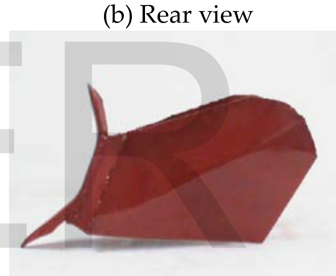
Jha, 2011). The furrow opener in the seed cum fertilizer drill is an important working element which is required to place the seed and fertilizer simultaneously in the seed bed and to create a suitable physical environment around the seed for good germination and plant growth. In most of the commercially available seed cum fertilizer drills, plain shovel type of furrow opener is used, which fails to perform the required functions of furrow opener. In tractor operated seed cum fertilizer drill which makes use of shovel type furrow openers only without shoe, the problem of soil sticking in seed and fertilizer tube arises causing restriction in the free flow of seed and fertilizer through the tubes and this results in uneven deposit of seed and fertilizer in the rows. Modification to the existing furrow opener is basically required looking into the problem of soil sticking in the tubes and proper covering of soil over the dropped seeds. Considering the above facts, a study was undertaken on the development of a shoe attachment to the existing furrow opener with the objectives of achieving its desired performance. The developed unit has been evaluated and compared with regards to its performance and draft requirement with the existing plain shovel.

Development of shoe attachment

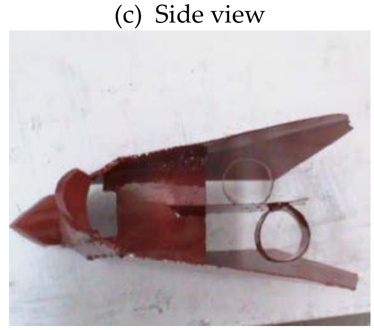
Furrow opener is generally selected to open the furrow for seed and fertilizer application at desirable depth and then to cover them. The draft requirement is an important factor while selecting the furrow opener for a particular farm situation. Draft and power requirement data are used to determine the size of power sources and to calculate cost of energy for different tillage implements. There are different types of furrow opener but in this study an attachment is provided with shovel mostly prevalent in seed cum fertilizer drill in the state of Odisha. In this study, a shoe attachment was designed and fabricated to the plane shovels used in commercially available tractor operated 9 row seed cum fertilizer drill (Khandai, 2013). The developed furrow opener with shoe attachment is shown in the figure below. However, during fabrication of 9 such units for the tractor operated seed cum fertilizer drill, only the shoe attachment was made so that they could be attached to the existing plane shovels for field test. The fabricated shoe attachment as well as the dimensions of the developed prototype unit is shown in Fig. 1.

(a) Front view

(b) Rear view



(c) Side view



(d) Top view

Fig. 1a: Different views of the prototype

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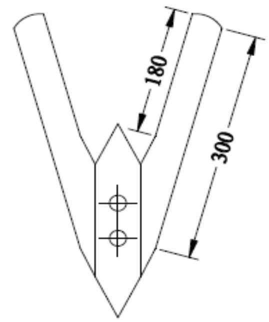
(a) Front View

(b)Rear view

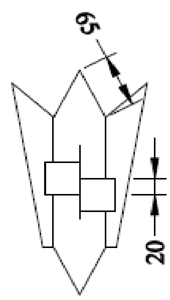
(c) Side view

(d) Top view

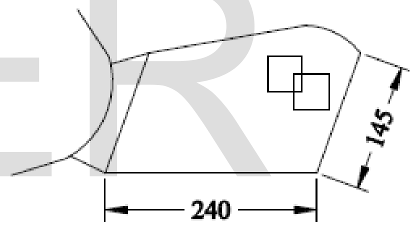
Fig. 1b: Different views of the fabricated shoe attachment



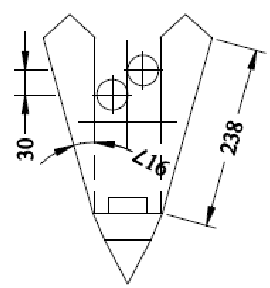
Front view



Rear view



Side view



Top view

(All dimensions are in mm)

Fig. 1c: Dimensions of the developed prototype furrow opener

The weight of different furrow openers studied is given below.

Plane shovel	0.75 kg
Prototype	2.74 kg
Shoe attachment only	2.59 kg

Materials and Methods

The study was conducted in a test soil bin of the Department of Farm Machinery and Power, OUAT, Bhubaneswar, Odisha during 2012, with provision to measure the draft of the test furrow opener with facilities to vary operational and soil parameters. The study was carried out in sandy loam type of soil (sand 76 %, silt 10 % and clay 14 %) at the varied moisture level, depth of operation and speeds of operation for three types of furrow openers like prototype, plane shovel and shovel attachment (fabricated). Further, the furrow parameters studied include; the furrow bottom, soil throw and soil coverage after passage of furrow opener in the soil bin.

Soil Bin

The soil bin comprised of a stationary bin, a tool carrier to attach desired implement, soil processing trolley, test trolley, power transmission system, control unit and data acquisition system for recording and display of the collected data in the computer. The bin was 15.0 m long, 1.8 m wide and 0.6 m deep. The two rails, one on top of each side of the bin wall were used for supporting the soil processing as well as implement trolleys. The test soil bed was of 12.0 m long and 1.2 m wide over which all test furrow openers are operated for draft measurement. The soil processing trolley consists of a frame, rotary tiller, leveling blade and roller for tilling, leveling and compacting the soil respectively to obtain the desired soil strength. A water sprayer provided in the processing trolley is used for spraying water on the soil to maintain the desired average moisture level. The different speeds of operation were obtained by choosing suitable gear of a gear reduction unit coupled to the input shaft of the revolving drum, which was attached to the soil processing trolley with stainless steel rope. A control unit placed outside the soil bin controlled the direction of movement of the soil processing trolley. The testing implement was mounted on the frame of the implement trolley where screw jack arrangements were provided to vary the depth of operation.

The test trolley consists of an extended octagonal ring transducer (EORT) of 1000 N capacity for draft measurement, cone penetrometer with 1 kN load cell with cone diameter of 19 mm for measuring soil resistance and a linear voltage displacement transducer with linear displacement range of 0-200 mm. the data acquisition is done by HBM Spider 8 data logger with provision for 8 channels recorder for interpretation of data in the computer. The photograph of experimental soil bin is shown in Fig. 2.

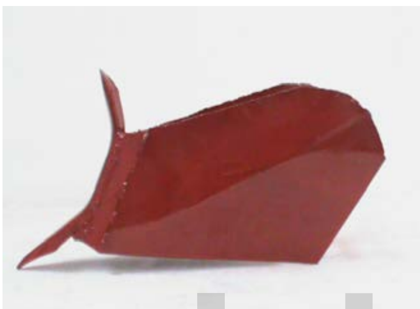
Fig. 2: Experimental soil bin

Before starting the experiment, the soil bed was prepared to achieve the required levels of cone penetration resistance. Firstly, the tiller was used to pulverize the soil after spraying water to achieve the required moisture content. Then, the soil was leveled with the leveling blade and compacted by the roller to achieve the required cone penetration resistance. At the end of each soil preparation, soil cone penetrometer attached to the soil bin was used for measuring the cone penetration resistance to a depth of 0.15m at intervals of 2.5m at three locations in the soil bin .The locations were chosen so as not to interfere with actual tillage tests. To get soil uniformity, the soil bed preparation was repeated if the cone penetration resistances were significantly different from each other.

Experiment Layout

Laboratory experiments in the Test Soil Bin were conducted with the developed furrow opener (prototype), fabricated with attachment and only shovel one at a time to determine the effect of operational parameters (moisture content, speed of operation and depth of operation) on draft requirements in a reference soil condition. The three types of furrow openers such as shovel, shoe with shovel (developed prototype) and fabricated shoe attachment are shown in Fig. 3 (a, b and c).

(a) Shovel



(b) Prototype

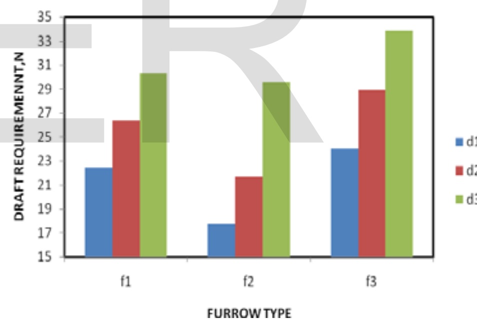
(c) Shoe attachment (fabricated)

Fig. 3: Three types of furrow openers taken for test

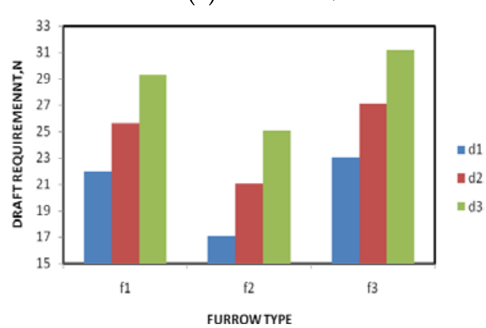
The experiments were conducted in sandy loam soil for three types of furrow opener like developed furrow opener prototype (Furrow 1), plain shovel (Furrow 2) and shovel with shoe attachment (Furrow 3) with moisture contents within 8-9%, 11-12%, 14-15% and 17-18% (wb). Soil strength was maintained between 800 kPa to 1000 kPa. Four speeds of operation (0.8 km/h, 1.2km/h, 1.6km/h and 2 km/h) and three depths (50 mm, 60mm and 70 mm) were selected for study. The data collected through experiments were analyzed statistically by following completely randomized design (CRD) method.

Results and Discussion

The results on the effects of operational parameter on draft requirement and soil coverage in the furrow have been presented and discussed in this section. The effects of the operational parameters like moisture content, depth and speed within the range studied on the draft requirement for different furrow openers are presented in figs. 4, 5, 6 and 7. These graphs reveal that the draft requirement of the plane shovel is minimum followed by the prototype and the fabricated shoe attachment with shovel at all operational levels. The draft requirements for the developed shoe attachment were found to be 30-35 % more than the plain shovel. The draft requirement decreased gradually with increase in moisture content for all three furrow types at three different depths for each speed level. This may be attributed to the fact that the soil resistance reduces with increase in the moisture content within the range studied. The draft requirements also increased linearly with increase in depth for all test conditions like speed and moisture content.



(a) m.c.=8-9%



(b) m.c.=10-11%

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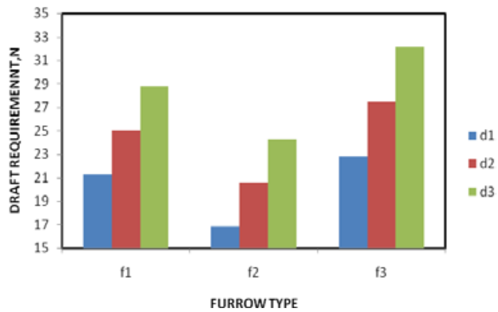
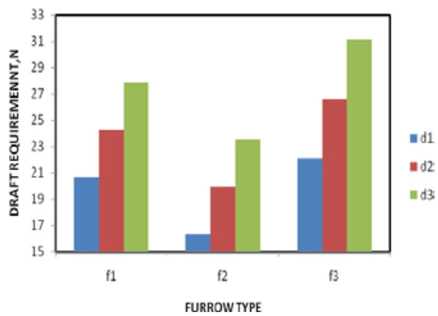
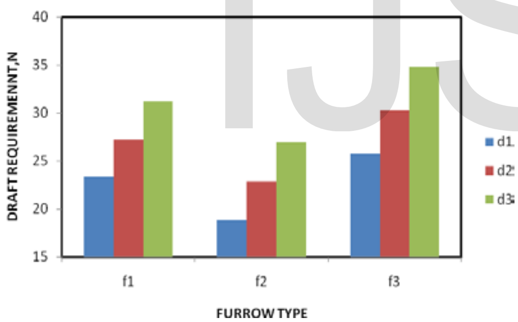


(c) m.c.=13-14%

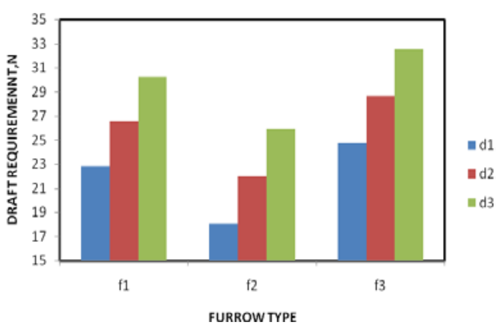


(d) m.c.=17-18%

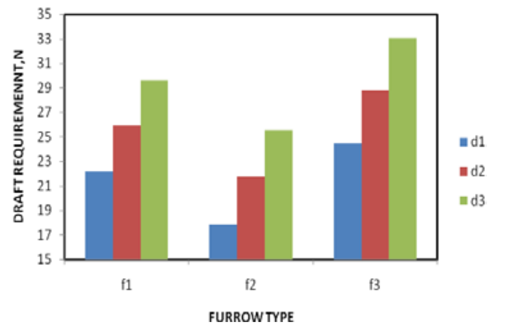
Fig. 4: Effect of moisture content and depth on draft for different furrow type at speed 0.8km/h



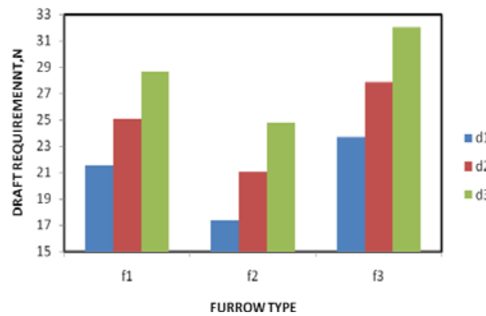
(a) m.c.=8-9%



(b) m.c.=10-11%

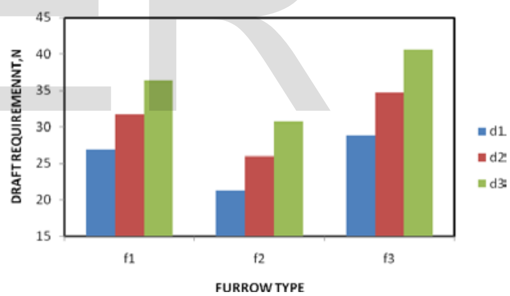


(c) m.c.=13-14%

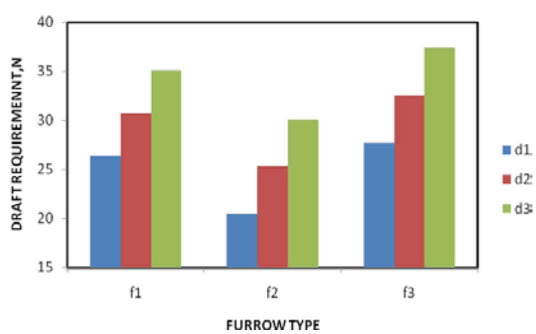


(d) m.c.=17-18%

Fig. 5: Effect of moisture content and depth on draft for different furrow type at speed 1.2 km/h



(a) m.c.=8-9%



(b) mc.=10-11%

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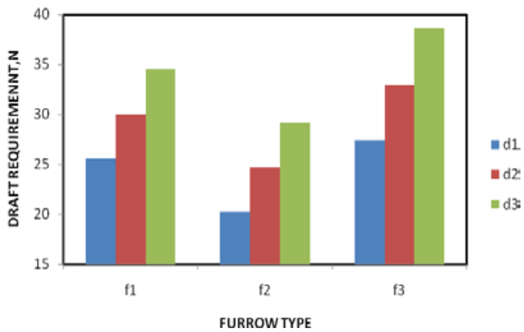
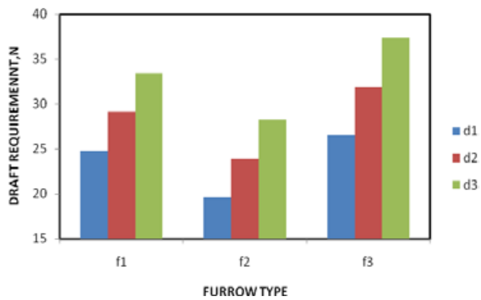
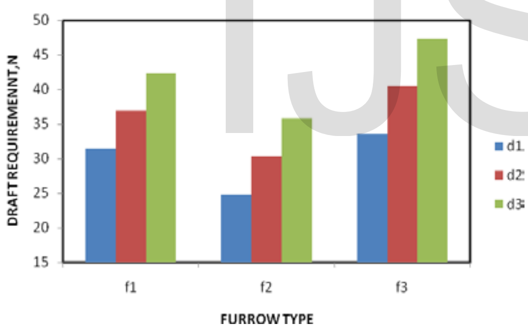


(c) m.c.=13-14%

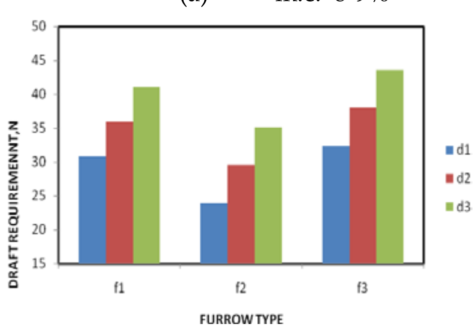


(d) m.c.=17-18%

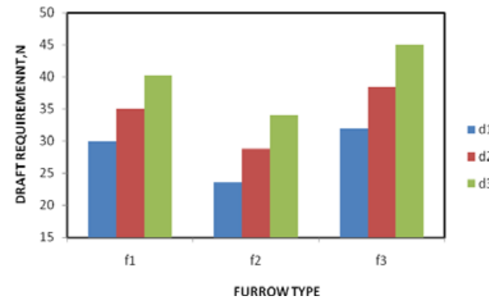
Fig. 6: Effect of moisture content and depth on draft for different furrow type at speed 1.6 km/h



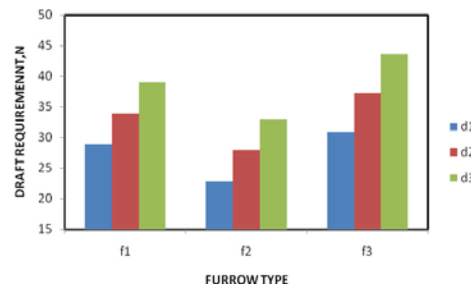
(a) m.c.=8-9%



(b) m.c.=10-11%



(c) m.c.=13-14%



(d) m.c.=17-18%

Fig. 7: Effect of moisture content and depth on draft for different furrow type at speed 2 km/h

Similarly, the furrow parameters studied during the course of experiments were furrow bottom, soil throw and soil coverage after passage of furrow opener in the soil bin. It was found that at moisture level of 10-11%, furrow opening and coverage was better than at other moisture levels. The draft requirement reduced with increase in soil moisture content. However, when the moisture content increased beyond 12% , the soil coverage in the furrow was less than that observed at lesser moisture content levels. When moisture content increased upto 17-18%, soil sticked to the furrow opener for which soil covering was not proper. The heaps of soil were formed at the two sides of the furrow. So it is inferred that though draft requirement is more at less moisture content but considering the soil coverage which is one of the very important functions of furrow opener in seed cum fertiliser drill, the moisture level in the range of 10-11% is more appropriate for operating the furrow opener attched to seed cum fertilizer drills.

Conclusions

The major findings of the developed shoe attachment to the existing furrow opener of seed cum fertilizer drill are as follows,

i) The Test soil bin was found suitable to determine the draft requirement of the test furrow opener at various operational parameters.
ii) The draft requirement of the developed shoe attachment with shovel type furrow opener was found to be in the range of 25.7 N to 29.5 N in the speed range of 1.2km/h to 1.6 km/h.
iii) Considering different operational parameters such as moisture content, depth of operation and speed of operation, the draft requirements for the developed shoe attachment were 30-35 % more than the plane shovel but soil coverage in the developed unit was found better and was about 100 per cent higher than the plane shovel at all depths studied.
iv) The draft requirement of the developed shoe attachment was found very much suitable for the existing tractor operated seed cum fertiliser drills equipped with shovel type furrow openers only.

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