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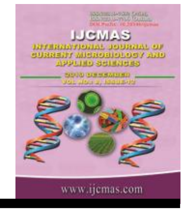

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Development and Evaluation of a Furrow Covering Device for Tractor Operated Seed-Cum-Fertilizer Drill under Controlled Laboratory Condition

Gunasagar Sahu*, Jyotirmay Mahapatra and Nrushinhananda Mahapatra

Department of Farm Machinery and Power, College of Agricultural Engineering and Technology, OUAT, Bhubaneswar-751 003, Odisha, India

**Corresponding author*

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A B S T R A C T

Proper tillage, precise placement and optimum coverage of seeds and fertilizers in the moist zone of soil are most critical for successful crop establishment. The present work was therefore taken up to study the soil coverage in the furrow with a developed furrow covering device with shovel and shoe type furrow opener. Experiments were conducted in the test soil bin with the three types of furrow openers like plain shovel, shovel with shoe and shovel+shoe+covering attachment with load of 5 kg to determine the performance on soil coverage and draft requirement. The draft requirement of the developed device with shovel and shoe type furrow openers were studied in sandy loam soil with a moisture content of 10 -11 % (wet basis) at a constant speed of 2.1 km/hr and at a depth of 80 mm. Soil strength was maintained between 300-400kPa throughout the experiment. From the experiment draft requirement for shovel, shovel with shoe and shovel+shoe+covering device with 5kg load was found to be 36.6 N, 41.0 N, 49.8N, respectively under the test conditions. The soil coverage data revealed that the developed furrow covering device resulted in best furrow coverage leaving the soil surface levelled both in the test soil bin and test under field condition. Although the attachment of the developed furrow covering device has draft requirement of 8.8N; considering the soil coverage which is very important in performance of seed-cum-fertilizer drill, the developed unit was found to be best in functional requirement of a tractor operated 9 tyne seed-cum-fertilizer drill.

Introduction

Timely sowing and precision placement of seed and fertilizers in the moist zone are most critical for successful crop establishment. Since the sowing of crops must be completed in a short span of time, use of appropriate implements is necessary to cover large area before the seed zone dries out. Suitable implements have been recommended for various locations to meet this requirement. These are designed to suit the soil type, crop and draught power availability. In many cases, the existing local implement used by the farmers have been improved to increase their working efficiency (Venkateswarlu, 2010). The seeding device is required to make furrow in the moist soil zone with minimum soil disturbance and it must cover the seed properly to provide a suitable environment for germination (Magar *et al*. 2010). An ideal seed environment is one in which the seed depth and soil firmness provide adequate moisture, oxygen, and temperature to the seed but without excessive soil firmness that retards root development and seedling emergence (Srivastava *et al*., 1993). This requires an optimal compaction force by the covering device as per the soil type and moisture content. As the soil is normally warmer near the surface at planting time and warmer soil promotes seed germination and seedling may not have sufficient strength to emerge if the seed is planted too deep in firm soil. Thus there is an optimum depth of planting which varies with the type of crop and other factors (Morrison and Gerik, 1985).

Different types of seed drills and seed cum fertilizer drills have been developed to suit various sources of power available in farmer's fields. These machines have been introduced and popularized to facilitate seeding operation and to maximize crop yields. Many experiments indicate that optimum plant population achieved by seeding equipment significantly contributes to higher yields. For those different functions, there are different components in seed-cum-fertilizer drill. But our study confined to furrow openers and covering devices. A furrow opener is an important component of a seed-cum-fertilizer drill or planter. The furrow openers are provided in a seed-cum-fertilizer drill for opening the furrows before dropping the seeds and fertilizers and after dropping, the covering device closes the furrows. The seed tube conducts the seed from the feed mechanism into the boot from where they fall into the furrows. The types of furrow openers used vary with soil and operating conditions. The common types of furrow openers used for conventional tillage are hoe, shovel, shoe, runner, single disc, double disc, chisel and inverted T furrow openers. Common types of furrow openers used for minimum and no-tillage systems are hoe, chisel, winged chisel, inverted T and triple-disc furrow openers. Some of the furrow openers are used in seed drills, each opener having a single seed tube. Others are used in seed cum fertilizer drills and often have a single boot with two tubes for both seed and fertilizer.

The seed cum fertilizer drill (tractor and bullock drawn) is currently most popular in India for line and timely sowing of seeds within the available small time from the harvest of one crop to the sowing of the next crop (Shrivastava and Jha, 2011). 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 which restricts the free flow of seed and fertilizer through the tubes and this results in uneven deposit of seed and fertilizer in the rows. Provision of a shoe attachment to this equipment would help solve the problem of soil sticking in the tubes. However, past work has revealed that covering of furrow after dropping of seeds needs improvement. For this purpose, a furrow covering attachment along with the shoe has been developed. Considering the above facts, a study was undertaken to develop a furrow covering device and compared it with the shoe type device in a controlled test soil bin condition. Then the effect of the attachment on furrow covering was studied in field condition.

Materials and Methods

The experiments for the study were conducted in the soil bin laboratory of the Department of Farm Machinery and Power, OUAT, Bhubaneswar, Odisha. The study was limited to sandy loam and soil moisture content (10-11% w.b.) as well as normal soil resistance (300-400 kPa) level which usually prevailed in the field condition for operation in soft soil. Three types of devices such as a shovel, shovel with shoe and shovel+shoe+developed furrow covering device were used in the study and evaluated on the basis of draft requirement during their operation and the type of soil profile created by corresponding devices. All the experiments were conducted during 2014-15.

Soil bin

The experimental soil bin comprised a stationary bin, a tool carrier to attach the desired implement, soil processing trolley, power transmission system, control unit, and data acquisition system record and display 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 testing devices were operated for draft measurement. The soil processing trolley consists of a frame, rotary tiller, levelling blade and roller for levelling and compacting the soil to obtain the desired soil strength (as shown in Fig. 1). A water sprayer provided in the processing trolley was used to apply water on the soil to maintain the desired average moisture level. Different speeds of operation were obtained by choosing suitable gear of a gear reduction unit coupled with 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 the 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 consisted 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 was done by using HBM Spider 8 data logger with provision for 8 channels recording (Fig. 2).

Experimental procedure

Experiments were conducted with the test furrow openers like shoe with shovel, shoe+shovel along with the furrow covering attachment with load of 5kg one at a time to determine the performance on soil coverage and draft requirement. The experiment was conducted in sandy loam soil with a moisture content of 10 -11% (w.b.) at a constant speed of 2.1 km/hr and at a depth of 80mm. Soil strength was maintained between 300-400kPa throughout the experiment. The observed data on draft requirement and soil coverage were obtained as per the procedure explained earlier and have been presented in the result section.

Soil description and soil bed preparation

Experiments were conducted under laboratory conditions in a sandy loam soil of moisture contain 10-11% (w.b). Before starting of experiments, 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 levelled with the levelling blade and compacted by the roller to achieve the required cone penetration resistance. Depth of roller, leveller and rotary is adjusted by hydraulic means. At the end of each soil preparation, soil cone penetrometer attached to the bin was used for measuring the cone penetration resistance to a depth of 0.15m at an interval 2.5m at three locations in the soil bin. The locations were 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 (Table 1).

Procedure for measurement of soil moisture content

The moisture content of soil was determined using oven drying method. The soil samples were collected at random, immediately after each tillage treatment for each study location. Each soil sample was collected in a well labelled container and weighed on a digital balance of precision 0.01gram and then oven dried at a temperature of 105°C in an oven for 24 hours. The soil moisture contents (wet basis) were computed using the following expression:

$$\text{Soil M. C (wet basis) in \%} = \frac{(m_2 - m_3)}{(m_2 - m_1)} \times 100$$

Where M.C = moisture content, %
m_1 = mass of container in grams, g
m_2 = mass of container in grams +wet soil sample in grams, g
m_3 = mass of container in grams +oven dried soil sample in grams, g

Procedure for measurement of soil strength

Soil strength at different locations in the soil bed (to a depth of 0.15m at intervals of 2.5m at three locations in the soil bin) was measured by soil cone penetrometer with base diameter of 25.6 mm attached to the soil bin. Cone tip along with the sleeve of cone penetrometer penetrated through the soil by operating the lever attached to the hydraulic system in the processing trolley. A force transducer (U9B) was attached to the end of the sleeve for recording force applied for penetration. Similarly, an LVDT transducer was attached to record the depth of penetration of cone through the soil.

Simultaneous action of penetration of cone of the cone penetrometer and recording were made on the laptop (connected through the data acquisition system (Spider-8) via force transducer & LVDT). The unit of force & penetration depth measurement was in Newton and millimeter, respectively. It may be noted that initialization of recording for the force applied and depth of penetration were made while the tip had already been penetrated and base of the cone was just at the ground level. The cone index in Pascal was found out for each measurement.

Procedure for measurement of depth of furrow

There was a provision for vertical up and down motion of the EORT along with the furrow opener under test by the hydraulic system. A scale was attached to the frame of the test trolley. The initial position of the furrow opener (when the tip of the shovel just touched the ground level) was marked. The suitable depth as per the requirement of the observation 80mm was applied to the furrow opener by the hydraulic lever and scale reading. It may be noted that an opening was previously prepared on the soil bed just in front of the initial position of furrow opener.

Procedure for measurement of draft

The laptop was opened with Catman Easy software. The constant voltage power supply was made on with the adjustment of 10V. Data acquisition system (Spider-8) was made on & the signal from the data acquisition system was connected to the laptop through USB cable. The sensor of the EORT was connected to the data acquisition system through a cable. The stress signal from EORT was converted to electrical signal and after suitable signal processing through data acquisition system it transferred to the laptop in recordable form. Suitable adjustment regarding initial value range etc. was made on the software. The display was opened with a real-time graph (for continuous measurement of draft in Y-axis versus time in X-axis) and a digital display recorder (for maximum draft value).While the test furrow opener attached to the EORT moved through the soil at particular speed and depth, the laptop records the draft in mV/V. This value was converted into the actual value of draft in Kg with the calibration curve.

Furrow covering device

The furrow covering device was fabricated using mild steel sheet with a provision to attached it with shoe, which also had a load of 5 kg on the top to provide a gentle press to the soil above the dropped seeds. The developed furrow covering device is shown in Figure 5 (a and b).

Results and Discussion

Calibration of extended octagonal ring transducer (EORT)

The EORT was calibrated by applying known weights and recording of respective electrical strains in the data logger. All the arrangements using EORT and spring dynamometer are shown in Figure 3 (a,b). A graph was plotted between the electrical strains and known weights and from the curve, the calibration equation was developed (Fig. 4). From the graph between the electrical strain and the load on the EORT, it was observed that the straight-line curve represented best fit with high value of the coefficient of determination (R^2) 0.9973, which could be satisfactorily used to determine the draft experienced on the testing devices at various operational conditions.

Draft requirement of the testing devices

The draft requirement of three types of testing devices such as a shovel, shovel with shoe and shovel+shoe+soil covering device with 5kg load were determined at a soil moisture content of 10-11%(w.b.), depth of operation 80 mm and speed of operation of 2.1 km/hr and shown in Figure 6 (a, b and c). The data revealed that the draft requirements for the above testing devices were found to be 36.6N, 41.0N, 49.8N respectively under the test conditions. A higher draft requirement for the developed furrow covering device can be attributed to higher load of the developed unit in comparison to shovel only and shovel with shoe.

Table.1 Some physical properties of the experimental soil

Parameters	Values
Percentage of Sand, %	80.56
Percentage of Silt, %	8.80
Percentage of Clay, %	10.64
Textural class	Sandy loam
Bulk density (g/cm^3)	1.54
Particle density (g/cm^3)	2.63

Fig.1 Soil bin arrangements

Fig.2 Data Acquisition System (HBM-Spider8) With Laptop and Control panel

Fig.3 Extended octagonal ring transducer (EORT) and the calibration arrangements using a spring dynamometer and a pulley

(a) EORT

(b) Dynamometer and pulley arrangement

Fig.4 Calibration curve of the EORT

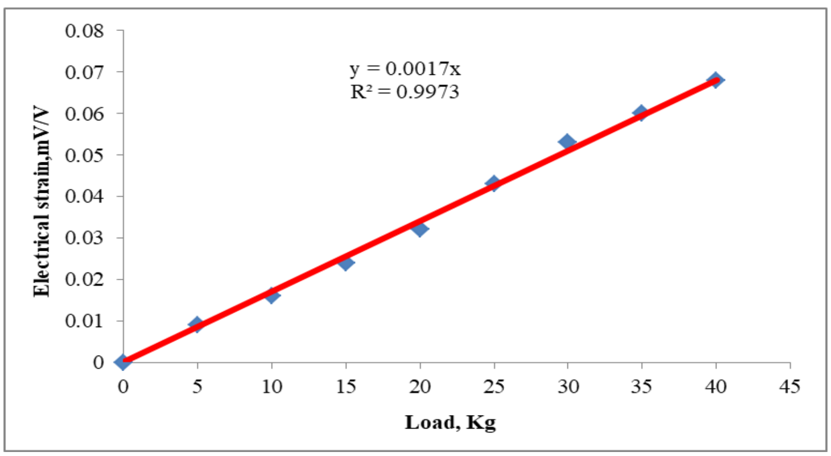

Fig.5 (a) Developed furrow covering device and (b) the covering device in action

(a)

(b)

Fig.6 Comparative study was carried out using (a) only shovel (b) shovel with shoe and(c) shovel with shoe and developed covering device

(a) shovel (b)shovel with shoe (c)Shoe+Shovel+ Covering device with 5 kg load

Fig.7 Soil coverage profiles as obtained from the test

(a) shovel (b) shovel with shoe (c) Shoe+Shovel+ Covering device with 5 kg load

Fig.8 Graphical representation of the soil coverage profile after operation using (a) a shovel (b) shovel with shoe and (c) shovel with shoe and developed covering device

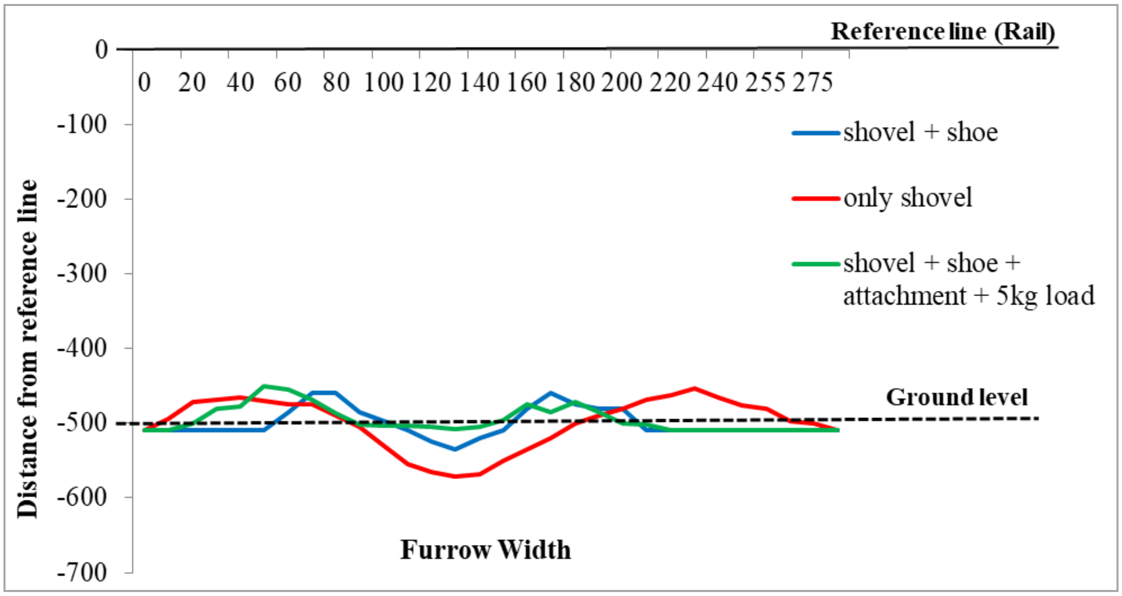

Fig.9 Testing of the developed unit in field condition

Soil coverage

The soil coverage profile of different testing units as obtained in the test soil bin experiment is presented in Figure 7(a, b and c). From the observations, it could be inferred that the developed unit results in best furrow coverage. The comparative performance of the furrow covering devices is presented graphically which is shown in Figure 8. The green colour line in figure 8, which represents the soil coverage profile for the developed covering device, clearly shows the best coverage of soil among the other devices.

Field test

The developed device was tested on the tractor operated seed cum fertilizer drill under field condition (M.C. 4.5% and soil type-sandy loam soil) in the central farm (shown in Fig. 9). From the study, it can be inferred that, although the draft requirement of the developed device is little higher than the other devices, considering the soil coverage which is very important in performance of seed cum fertilizer drill, the developed unit was found to be best in functional requirement of a tractor operated 9 tyne seed-cum-fertilizer drill.

In conclusion, the draft requirement and soil coverage were studied in the test soil bin for the above test tools and their performances were compared. From the experiment draft requirement for shovel, shovel with shoe and shovel+shoe+covering device with 5kg load was found to be 36.6 N, 41.0 N, 49.8 N respectively under the test conditions. The soil coverage data revealed that the developed furrow covering device resulted in best furrow coverage leaving the soil surface leveled both in the test soil bin and test under field condition.

From the study, it can be inferred that, although the draft requirement of the developed device is higher than the other devices, the developed unit was found to be best in functional requirement of a tractor operated 9 tyne seed cum fertilizer drill.

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