MODIFICATION AND EVALUATION OF A PEDAL DRIVEN SEED DRILL

F. B. Akande, O. E. Ajiki, O. Adekoya and K.O. Oriola*
Department of Agricultural Engineering,
Ladoke Akintola University of Technology, Ogbomoso, Nigeria.
E-mail: kazzyoris@yahoo.com

ABSTRACT: *An existing pedal driven seed drill was test run, the problem with the low level of performance was studied, and modifications were made on the existing pedal driven seed drill for better performance. The angle of repose was used to calculate the volume of the seed hopper, shaft design of the solid agitator, diameter of both the front and rear wheel and the length of chain were calculated. The newly fabricated seed drill was calibrated and tested on the field using paddy rice and sorghum. The results of the calibration shows a seed discharge rate of 43.24 kg/ha for paddy rice and 432.2 kg/ha for sorghum. The speed, theoretical and effective field capacity were calculated to be 1.89 km/h, 0.174 ha/h, and 0.086084 ha/hr. The efficiency of the machine was evaluated to be 49.5 %. The seed drill has a seeding rate of 43.24 kg/ha.*

Keywords: Pedal-Driven Seed Drill, Seed Rate, Effective Field Capacity, Theoretical Field Capacity, Field Efficiency.
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INTRODUCTION

A seed drill is a sowing device that precisely positions seeds in the soil and then covers them. The seed drill allows farmers to sow seeds in well-spaced rows at specific depths at a specific seed rate. Before the invention, farmers planted the seeds by carrying the seeds in a bag and walking up and down the field throwing or broadcasting the seed. They broadcast the seed by hand on to the ploughed and harrowed ground. The invention of the seed drill increased crops and profits for the farmer (Heege and Billot, 1999).

Agricultural mechanization embraces the use of tools, implements, and machines for a wide range of farm operations from land preparation to planting, harvesting, on-farm processing, storage, and marketing of products. Sources of farm power include hand tools, draft animals, and mechanically-powered technologies (Adrianus, 1999). Agricultural mechanization often follows various stages, starting from the use of mechanical power for power-intensive operations that require little control (such as milling, threshing, water pumping, or land preparation, followed by controlintensive operations (such as harvesting, weeding, and adapting farming systems and cropping patterns) to increased use of mechanically powered technologies, and finally to automation of production.

In Nigeria, where the cost of imported goods rises to a large extent related to the foreign exchange rates, thereby making it difficult for local farmers to practice mechanized farming. The tractor drawn seed drills cause compaction of the soil and have high fuel consumption, which increases the initial cost of production. Also animal drawn seed drill requires trained personnel to manage the animal used. The cost of purchasing or maintain a tractor is high and beyond the reach of the local farmers.

It can improve productivity and reduce the operating cost for farmers, to develop a pedal driven seed drill and the cost of imported goods will not be necessary. It is useful to generate employment in the rural areas. Pedal driven seed drill is efficient and affordable by the farmers. The pedal driven seed drill will reduce the initial cost of production resulted from fuel usage and eliminate the use of personnel to manage the animal. This research is to develop a pedal driven seed drill for low income farmers which will reduce soil compaction and which can operate on a small farmland has this has become a necessity.

Jain and Grace (2002) stated that seed drill is developed to save time, fuel and irrigation expenses. The mechanism of a seed drill, which distributes and delivers the seeds from the hopper at selected rates, is called seed metering mechanism. The metering mechanism functions as the brain of any given seed drill. It meters the number of seed to be discharged at equidistant position as the seed drill progresses in its forward motion. The seed rate is controlled by change of metering disc for required spacing for the particular crop while depth of sowing is adjusted by the setting of furrow opener.

The metering devices with fluted roller are widely used in tractor-drawn seed drills in Europe and North America (Bansal *et al.,* 1989). These have some advantages such as simple constructions, light weights, easy adjustment of seed rate (Ryu and Kim, 1998). The aim of this study is to modify a pedal driven seed drill for low income farmers.

MATERIALS AND METHODS

The design criteria, material used, and the procedures adopted in construction may be modified to suit the local situation. It is suggested that low cost and readily available materials and standard bicycle parts can be substituted whenever possible. Change in construction method and dimensions should be made according to the availability of materials and manufacturing capability.

Design Consideration

During design and modification of seed drill; the following consideration were made:

a) Convenient and economical components
b) It employ locally available materials and no specialise skills is needed.
c) The power requirement should not be too high.
d) Safety of Operation
e) Cost of Construction

Machine Description and Operation

The machine consists of the following units: the hopper, bearings, agitator, wheels, seed metering devices, tyres in figure 1 and 2. Angle of repose of 28.5^0 was used in the construction of the seed hopper for easy movement of seed into the agitator. Mild steel was cut and welded into specific hopper size in such a way that the length and breadth of hopper was 835mm and 360mm, which was constructed with perpendicular distance of 400 mm between the upper and lower part. The total volume of the hopper (V_H) calculated to be 0.111 m^3.

Below the hopper is a metering mechanism that is made up of shaft and rolling steel with casing. The rolling steel was made in such a way that pipe steel was cut and steel was attached at its body, this steel was tightened with bolt and nut to the shaft then attached the casing to protect the metering mechanism and to ensure proper dropping of seeds into the delivery tube. The hopper was supported with steel to make it more rigid and to create avenue for the tricycle part to be attached. The right wheel supply power to the metering mechanism with the help of sprocket and chain. Inside the hopper is attached an agitator which mixes seeds together, thereby allowing it to drop seed to the metering mechanism.

The hand driven pedal seed drill was fabricated using locally available materials such as mild steel, chain, wheel, sprocket, motorcycle tyre and seat. The chain transmit power from pedal to the front wheel, and the movement of the front wheel aid the movement of the seed drill that was attached to the back of the tricycle. The fabricated seed drill is powered from a hand driven pedal tricycle.

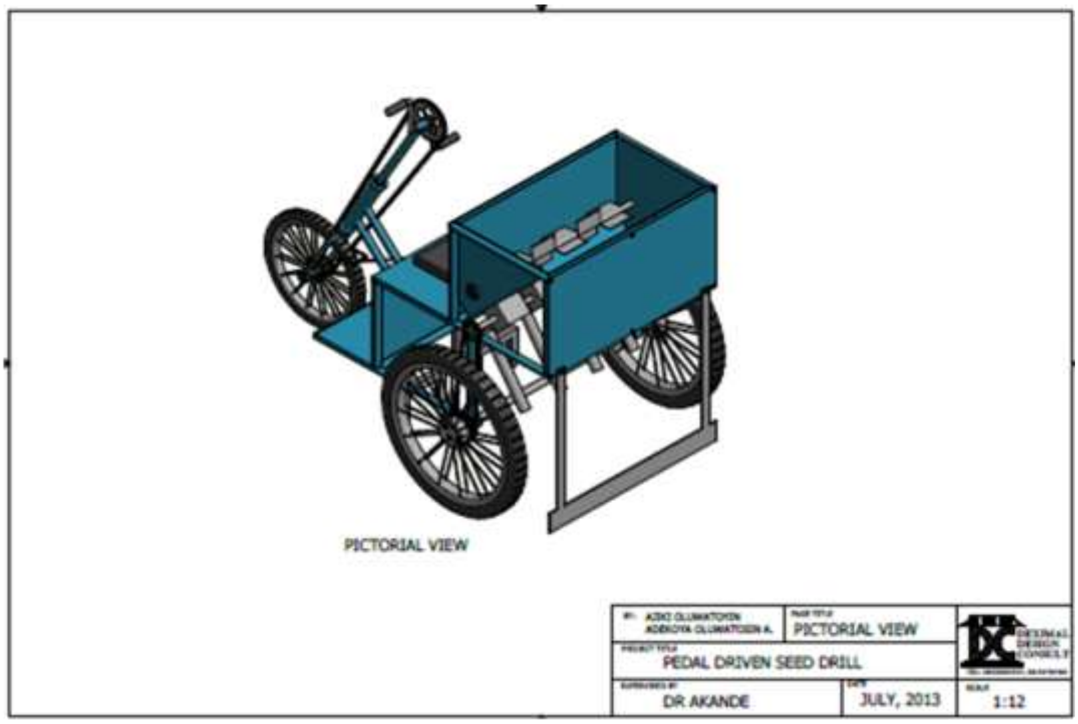

Figure 1: Isometric View of the Seed Drill

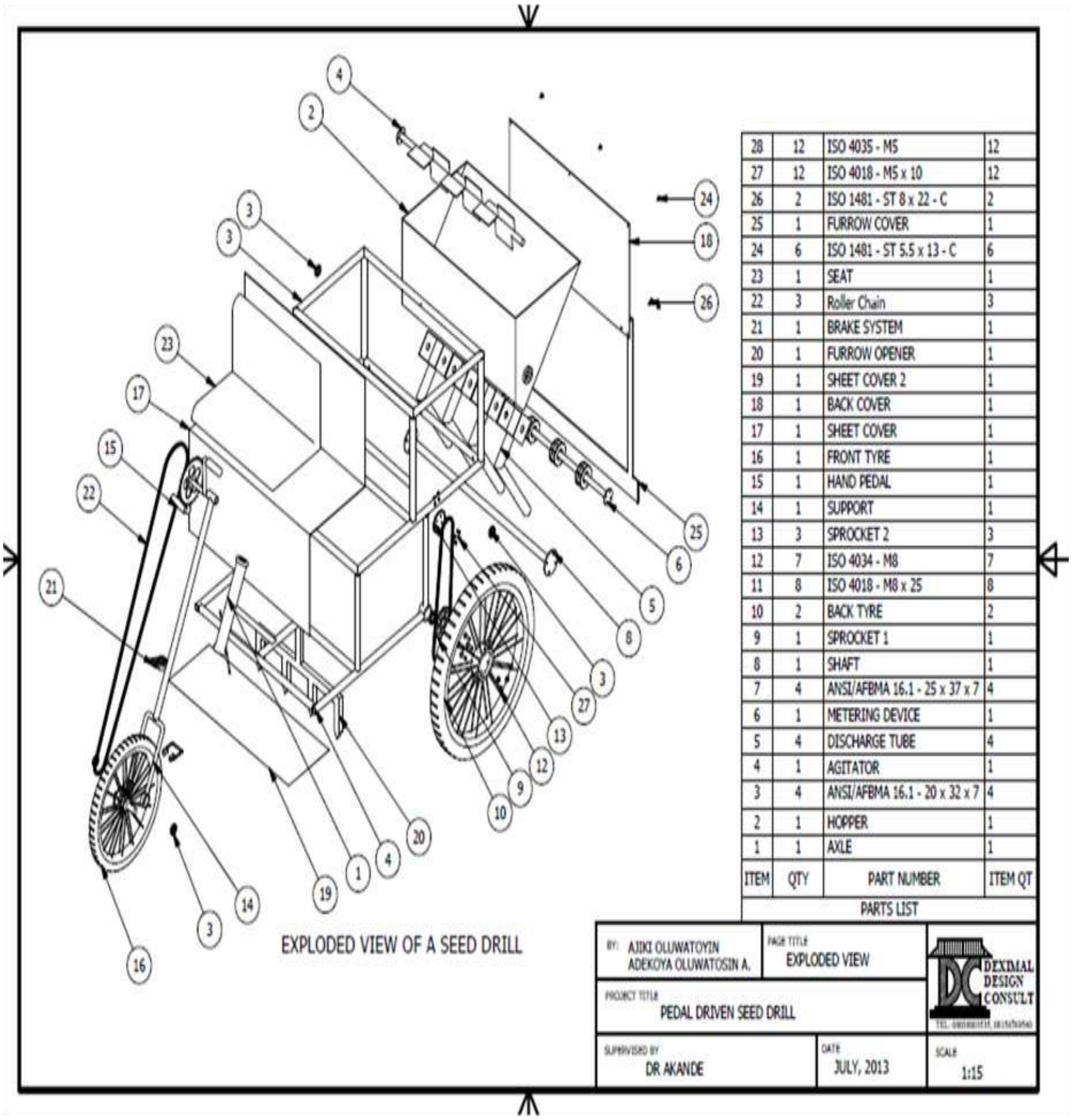

Figure 2: Exploded View of the Seed Drill

Design Calculation

The Angle of Repose

The angle of repose is used for the designing of the seed hopper. The angle of repose for different grains is presented in the Table 1.

Seed Hopper

Volume of the hopper is calculated using equation 1. The volume calculated is the maximum volume of the seeds it can occupy.

Using the volume of a frustum of a pyramid

$$V_h = \frac{h}{3}(A + A' + \sqrt{A.A'}) \quad (1)$$

Where,

V_h = Volume of the hopper (cm^3)

H = Vertical height section

A = Area of larger base

A = Area of the smaller base

Larger base = $l \times b$

= 360 mm × 836 mm

= 300960 mm^2

= 0.3009 m^2

Smaller base area = $l \times b_s$

Where b_s = breadth of smaller area = 100 mm

= 836 mm× 100 mm

= 83600 mm^2

= 0.0836 m^2

But; h = 330 mm

Therefore;

$V = \frac{0.33}{3}(0.30096 + 0.0836 + \sqrt{0.30096 + 0.0836}$

= 0.11(0.38456 + 0.62013)

= 0.11(1.004689)

= 0.11052

= 0.111 m^3

Table 1: Angle of Repose

Selected Seeds	Angle of Repose (θ)
Rice	41.1
Millet	27.9
Cowpea	28.1
Sorghum	28.5
Wheat	30.8

Source: (Ogbonnaya and Akande, 2007)

Shaft Design

For a solid shaft agitator

$T = \frac{\pi}{16} \text{ x } t \text{ x } d^3$ (Khurmi and Gupta, 2004) (2)

T = twisting moment (torque) acting upon the shaft (N/mm)

t = allowable shear stress (N/mm^2)

d = diameter of the shaft (mm)

The diameter = 150 mm

$t = \frac{ultimate\ shear\ stress\ (Tu)}{factor\ of safety\ (fS)}$ (3)

Taking T_u= 200 N/mm^2(assumption)

f.s = 1.5

$t = \frac{200N/mm^2}{1.5} = 133.33\ N/mm^2$

Now,

$T = \frac{\pi}{16} \times 133.33 \times 150^3$

$= 0.19642 \times 133.33 \times 3375000 = 88390647.32$ N/mm

T= 88390.64 N/m

To derive the power transmitted by the shaft,

$P = \frac{2\pi NT}{60}$ (Khurmi and Gupta, 2004) (4)

The shaft makes 100rev/min (assumption)

$P = \frac{2 \times 3.142 \times 100 \times 88390.64}{60} = 925.74$ kN

The Length of Chain

The length of chain is given,

$L = \frac{\pi}{2}(d_1 + d_2) + 2x + \frac{(d1 + d_2)^2}{4x}$ (5)

l = length of chain

d = diameter of the sprocket

x= distance between the driver and driven

$L = \frac{\pi}{2}(18 + 10) + 2 \times 73 + \frac{(18-10)^2}{4 \text{ x } 73}$

L = 43.988+ 146+ 0.219

L = 190.207 cm

L = 1.9021 m

Calibration of the Seed Drill

Calibration was done to determine the quantity of the seed to be sown. The quantity of seed discharged per hectare will be calculated using the following equation 6;

$$Q= \frac{q}{\pi Dnw} x10^4 \quad \text{(Akande } et\ al.\text{, 2013)} \quad (6)$$

Q = Seeding rate in kg/ha

q = Total quantity of seed collected from each delivery tube during testing (kg)

D = Diameter of the ground wheel (m)

n = Number of revolution of the ground wheel (rev/min)

w = Effective width of the machine (number of tube x distance between the tubes).

Field Efficiency

The relationship between effective field capacity (C_{eff}) and the field efficiency (E) is given as;

$$E = \frac{C_{eff}}{C_{th}} \times 100 \quad (7)$$

Effective field capacity (C_{eff}) shows in equation 8;

$$C_{eff} = \frac{Area\ of\ field}{Time\ taken\ to\ complete\ the\ sowing\ in\ minute} \quad (8)$$

Theoretical field capacity (C_{th}) shows in equation 9;

$$C_{th} = \text{Speed } X \text{ width of the seed drill} \quad (9)$$

RESULTS AND DISCUSSIONS

Tests were carried out on the fabricated low cost pedal driven seed drill and the functional parts of the machine can perform their expected functions. The performance tests were carried out on the field and the results are as presented.

The seeding rate of the machine for sorghum is calculated to be 432.36 kg/ha and 43.24 kg/ha for paddy rice. The linear speed of the machine is calculated to be 1.89 km/h. Theoretical Field Capacity of the machine is also calculated to be 0.174 ha/hr and Effective field capacity to be 0.086 ha/hr. The Field Efficiency of the machine is finally calculated to be 49.5%.

The number of seeds discharged from each tube were collected altogether and weighed after each number of revolutions of the ground wheel. It was also observed that as the number of turns increases, the quantity collected also increased for both sorghum and paddy rice as presented in Tables 2 and 3.

Table 2: Seeds Drop per Revolution of the Ground Wheel (Sorghum)

No. of Revolution of the Ground Wheel	Quantity Collected (kg)
2	0.10
4	0.30
6	0.40
8	0.60
10	0.70

Table 3: Seeds Drop per Revolution of the Ground Wheel (Paddy Rice)

No. of Revolution of the Ground Wheel	Quantity Collected (kg)
2	0.02
4	0.03
6	0.05
8	0.06
10	0.07

CONCLUSION

A pedal driven seed drill has been modified and fabricated at low cost. The seed drill has a seeding rate of 432.36kg/ha for sorghum and 43.24kg/ha for paddy rice was determined. The machine which was constructed from locally available materials at affordable price; is found efficient for farmers in the rural areas to improve their productivity.

REFERENCES

Adrianus, G. R. (1999). Agricultural Mechanization Strategy, Accessed on 14th of January, 2014. Available at www.unapcaem.org.

Akande, F.B., O Ibiyemi, A.S Adedoyin, and B.J. Fagbemiro, **(2013)**: Development and

Bansal, R.K, O.E.L Gharras, and J.H., Hamilton (1989).A Roller-Type Positive-Feed Mechanism for Seed Metering. *Journal of Agricultural Engineering Res.,* 43: 23-31.

Calibration of a Pedal-Driven Seed Drill. Proceeding of the 2nd International Conference on Engineering and Technology Research, Ladoke Akintola University of Technology, Ogbomoso, Nigeria. Vol. 2: 312-316.

Heege, H and J. F. Billot (1999). Seeders and Planters. In: CIGR Handbook of Agricultural Engineering Vol. III, Plant Production Engineering. Bill A. Stout (ed.), ASAE, 2950 Niles Road St. Joseph MI 49085-9659 USA.217-240.

Jain, S.C. and P. Grace (2002), Farm Machinery an Approach Text Book Published by Jain Brothers, New Delhi, India.

Khurmi, R.S and J.K. Gupta, (2004). A Textbook of Machine Design. Chand & Company Ltd, Ram Nagar, New Delhi, India pg. 104 – 700

Ogbonnaya, C. and F.B. Akande, (2007). Development of an Apparatus for Measuring Angle of Repose of Granular Materials. *Au Journal Tech_ Article* 10pg. 62-65

Ryu, I.H; and K.U. Kim,.(1998.). Design of Roller Type Metering Device for Precision Planting. Transaction of the ASAE. 41: 923-930.

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