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DEVELOPMENT OF BULLOCK DRAWN DRY PADDY SEED CUM FERTILIZER DRILL

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Abstract: A study was carried out on development of bullock drawn dry paddy seed cum fertilizer drill for upland cultivation. Based on the physical characteristics of seed, development of dry paddy seed cum fertilizer drill was done. The seed and fertilizer box was made trapezoidal for free flow of seeds and fertilizer without bridging. The cup feed mechanism was selected for metering paddy seeds as there is no seed damage and hence does not affect germination. For fertilizer metering, an adjustable orifice type mechanism was provided. A clutch is provided for disengaging power to the metering mechanism during turning. For seed and fertilizer placement, shoe and shovel type of furrow openers were used. A provision was made to adjust the row to row spacing as per requirement. The average theoretical field capacity, effective field capacity and field efficiency was 0.151 $ha \cdot h^{-1}$, 0.11 $ha \cdot h^{-1}$ and 75.96% respectively.

Key words: *upland, field capacity, efficiency*

INTRODUCTION

The traditional rice farming system in India broadly includes direct seeding and transplanting. The primary difference between the two methods is that in the transplanting method, seedlings are first raised in the seedbed before they are planted in the main field whereas in direct seeding, the seed is sown directly in the main field wither by broadcasting or row seeding in wet or dry field. Transplanting is most labour consuming operation during paddy cultivation. The cost of puddling and transplanting share 50 per cent of total production cost. The man days required for transplanting

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ranges from 50-60 man-days·ha^{-1}. The transplanting operation produced maximum paddy yield of 7875 kg·ha^{-1} whereas the highest paddy yield of 8666 kg·ha^{-1} was recorded by direct rice cultivation on dry soils with an increase of 10% over transplanting [9]. Direct seeding of rice on dry soils has been found most appropriate alternative to transplanting. It not only avoids puddling operations, raising and transplanting of nursery seedlings but also resulted in better yield than existing manual transplanting in some areas of the country. It involves less drudgery and labor and does not require preparation of nursery, care for it and pull the seedlings [7]. Drum seeders are developed for direct seeding of pregerminated paddy. The main problem observed in case of drum seeders is that the proper seed rate is not maintained and also uneven seed delivery is observed. Many seeds are dropped when the operator stops, and then no seeds are dropped until the seeder has moved forward for a small distance. This uneven seeding leads to an uneven plant stand and follow-up transplanting may be required. Drum seeding requires puddling and leveling of field, drainage as well as better methods of fertilizer application.

Direct dry seeding of paddy results in better yield of crop and water saving. The problem observed in case of dry seeding of paddy is weed infestation, lodging of plants because of less root anchorage. Sometimes the exposed seeds are lost due to birds and pests. The need for appropriate agricultural machine for direct dry seeding is felt as there is reduction in farm labor due to migration to urban areas and the labors are very costly and scares. Dry seeding of paddy along with the use of fertilizers is carried out to maintain the soil nutrient levels and increase crop yield levels. Considering the need, it is decided to develop three row bullock drawn dry paddy seed cum fertilizer drill for upland cultivation at department of farm machinery and power, CAET, Dapoli.

MATERIAL AND METHODS

The performance of a seed cum fertilizer drill depends on several variables that depend on the dimensions of the ground wheel, metering mechanism, peripheral velocity and uniformity of the seeds.

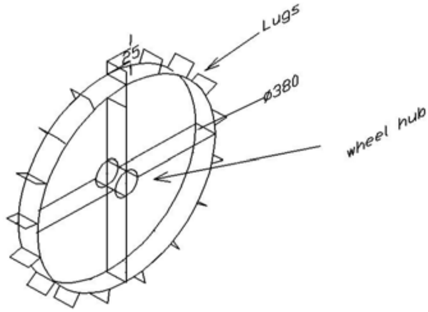

Figure 1. Isometric view of ground wheel of developed bullock drawn dry paddy seed cum fertilizer drill

Physical properties of paddy. Seed properties are important factors for optimizing the parameters of the design of seed drill. Hence attempt was made to study the physical properties of paddy seed in relation to seed metering mechanism. The paddy varieties selected for the study were classified as long and bold, long and medium, long and slender, short and bold, short and fine variety. The physical properties of paddy namely; thousand grain weight, size and surface area, bulk density, angle of repose were required for the design of metering mechanism [11].

Design of drive wheel. The drive wheel rim was made up of MS flat 40×5 mm. considering the lug height of 25 mm, 17 lugs were provided at periphery. Thus the diameter of lugged wheel was taken as 0.43 m.

Design of seed and fertilizer box. The seed cum fertilizer box was made of 16 SWG MS sheet. The cross section of the box is trapezoidal. . The shape of hopper is such that it ensures proper flow of seeds and fertilizer without bridging. Seed and fertilizer boxes have partition provided along the length of the box such that in one box it forms thee hoppers. The angle of inclination of the seed and fertilizer hopper with the vertical were 27° and 30° considering free flow of seeds and fertilizer respectively. The location of seed cum fertilizer box was 60 cm above the ground. This height of box helps to reduce the angle of inclination of seed delivery tubes.

Box capacity in terms of volume V_s is calculated in m^3 as:

$$V_s = Q_s \cdot \rho^{-1} \tag{1}$$

$$V_s = A \cdot L \tag{2}$$

where:

A [m^2] - cross sectional area,
L [m] - length of box,
Q_s [kg] - box capacity,
ρ [$kg{\cdot}m^3$] - density of material filled in box.

The length of the box is calculated as:

$$L_B = nd - 2b \tag{3}$$

where:

n [-] - number of furrow openers,
d [m] - distance between two furrow openers,
b [m] - distance between side wall of the box from the wheel.

For the 3 row paddy seed drill, the row to row spacing is 0.2 m, the actual length of box is 0.4 m. The cross sectional area of the seed and fertilizer box was determined by:

$$A = h\ (B + h \cot \alpha) \tag{4}$$

where:

h [m] - height of seed box,
B [m] - width of box,
α [deg] - angle of slope.

Therefore, $A = 0.22\ (0.25 + 0.22 \cot 63°) = 0.079\ m^2$

Volume of seed box is calculated as:

$$V = A \cdot L_B = 0.079 \cdot 0.4 = 0.0318\ m^3 \tag{5}$$

Box capacity:

$$Q_s = V_s \cdot \rho = 0.0328 \cdot 627 \approx 20\ kg \tag{6}$$

Using above equations, the area and the volume of the fertilizer box was 0.049 m^2 0.0149 m^3, respectively. The length of box was 300 mm. Thus, the box capacity was 16 kg, such that each hopper can be filled with 5.3 kg each.

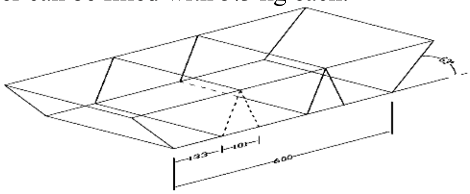

Figure 2. Isometric view of seed box of developed bullock drawn dry paddy seed cum fertilizer drill

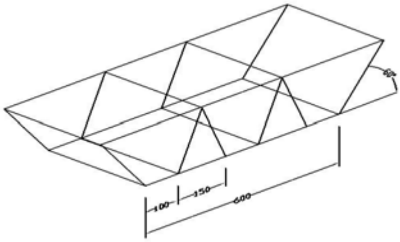

Figure 3. Isometric view of fertilizer box of developed bullock drawn dry paddy seed cum fertilizer drill

Seed metering mechanism. While designing the seed metering mechanism, prime consideration was given to use less sophisticated sowing technology, lower cost and easy to fabricate at a local workshop. Also, the metering mechanism should not cause any mechanical damage to the seed while in operation. Hence, cup feed mechanism was used so that there should not be any mechanical damage due to mechanical handling. A series of cups were fitted on the rim of a vertical rotating plate that dips into a shallow pool of seed, lifting a few at a time and carrying them over a top, where they are dropped into a delivery channel. The diameter of seed plate and the number of cups on the seed plate are determined as follows:

$$dc = \frac{V_c}{\pi \cdot N_c} \tag{7}$$

where:
d_c [cm] - diameter of seed plate,
V_c [$m \cdot s^{-1}$] - peripheral velocity of plate,
N_c [min^{-1}] - rpm of metering mechanism.

Number of cups on the seed plate is calculated as:

$$n = \frac{\pi \cdot D}{i \cdot x} \tag{8}$$

where:
n [-] - number of cups on the seed plate,
D [cm] - ground wheel diameter,
x [cm] - required seed to seed spacing,
i [-] - gear ratio (1:1).

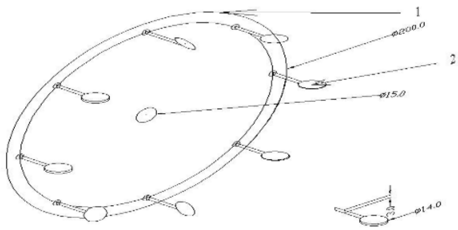

Figure 4. Seed metering mechanism used in developed bullock drawn dry paddy seed cum fertilizer drill

Fertilizer metering mechanism. The fertilizer metering device used in the drill was an adjustable orifice type. So at the bottom of the box a hole was provided and a lever was provided for sliding the plate. Meshing the holes regulates the flow of quantity of fertilizer. A ribbed rubber type agitator is placed over the holes to prevent bridging of granules in front of holes. Hole size on the plate is selected according to the requirement. Adjustable orifices are provided to control the fertilizer rate. The flow rate of fertilizer from the orifice is expressed by:

$$Q = F \cdot \rho_1 \cdot A_0 \cdot (2g \cdot P \cdot \rho_1^{-1})^{0.5} \quad (9)$$

where:

Q [$g \cdot s^{-1}$] - discharge rate,
F [-] - flow rate index of urea (const, 0.66) [4]
A_0 [mm] - area of opening of orifice,
ρ_1 [$kg \cdot m^{-3}$] - bulk density of material,
g [$m \cdot s^{-2}$] - acceleration due to gravity,
P [Pa] - static pressure produced by material.

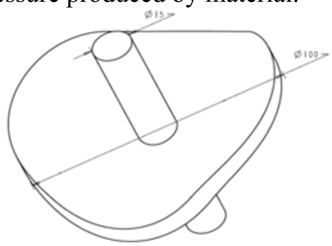

Figure 5. Fertilizer metering mechanism used in developed bullock drawn dry paddy seed cum fertilizer drill

The value of P is expressed as:

$$P = d_1 \cdot \rho_1 \cdot \gamma^{-1} \tan \varphi^{-1} \quad (10)$$

were:

φ [deg] - angle of internal friction of material (25° for MS sheet) ,
$\gamma = \tan^2 (45 - \varphi \cdot 2^{-1})$
$d_1 = d - d`$
d [cm] - diameter of orifice and $d`$ reduction in d due to flow.

Furrow opener. Furrow openers are used to place the seed at the desired depth with minimum dispersion. For seed placement, shoe type furrow openers were used as uniform depth of sowing was required [10]. Row to row distance can be changed by adjusting holes drilled in the frame. Furrow opener was made of medium carbon steel with 1800 mm^2 cross section. The rake angle is 33˚ in order to make cut the soil 3 to 5 cm deep. The relief angle of the blade is 8˚. Fertilizer was placed in the soil with the help of shovel type opener. The shovel type opener is a narrow pointed shovel, small l00 mm sized shovels were used for placing fertilizer at a depth of 5 cm. The leading edge of the opener is a sharp pointed triangle.

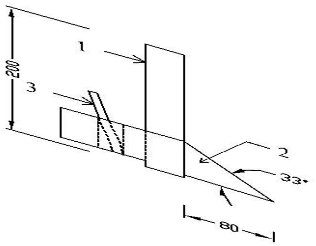

Figure 6. Isometric view of shoe type furrow opener of developed bullock drawn dry paddy seed cum fertilizer drill

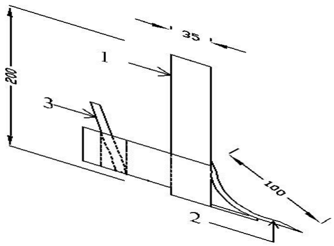

Figure 7. Isometric view of shovel type furrow opener of developed bullock drawn dry paddy seed cum fertilizer drill

Seed delivery tube. Polyethylene tubes of 25 mm diameter and 2 mm thick were used to convey seed from orifice to furrow opener by gravity. The inclination of the tubes from the vertical was kept smaller than 25˚ [8]. The time of fall of a seed though a tube is affected by the size and type of tube and bouncing of seeds against wall of the seed tube. The velocity of a seed falling freely from a height 'h' is given by:

$$V^2 = V_0^2 + 2gh \qquad (11)$$

where:

V [m·s^{-1}] - final velocity of seed due to fall,
V_0 [m·s^{-1}] - initial velocity of the seed,
g [m·s^{-2}] - gravitational acceleration, const. (9.81 m/s^2).

Power transmission unit. The power required to operate the seed and fertilizer metering mechanism was transmitted from the drive wheel though chain drive. Since the power transmitted in the seed drill is very low, the smallest size available chain, i.e. bicycle chain was used for animal drawn seed drill. For power transmission, 19 teeth a medium size 60 mm diameter sprocket of 12.9 mm pitch was fitted on drive wheel. Another sprocket of same size was used for seed and fertilizer metering shaft so that the transmission ratio of 1:1 was maintained.

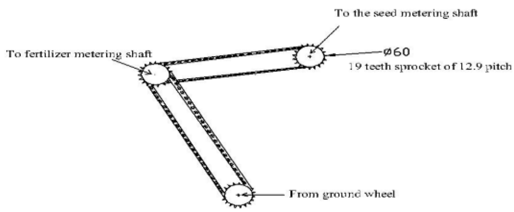

Figure 8. Power transmission system used for developed bullock drawn dry paddy seed cum fertilizer drill

Clutch. A clutch was provided to the ground wheel, so that during turning the power should not be transmitted to the metering mechanism. When the clutch was engaged to the drive wheel, the power was not transmitted to the metering shaft. So there should not be seed and fertilizer losses at the turning. Handle for the clutch was made of MS flat of 25×5 mm, length of 1100 mm connected to the driving wheel to the metering shaft. Dog clutch was used to disconnect the rotation of the drive wheel to the shaft.

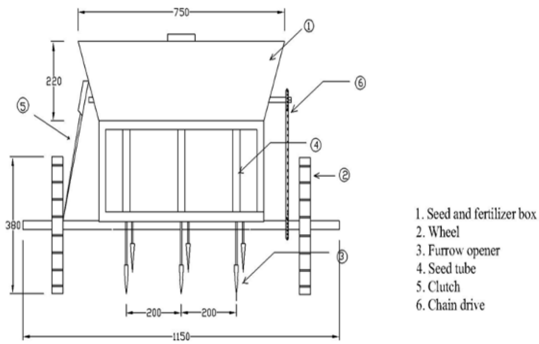

Figure 9. Front view of bullock drawn dry paddy seed cum fertilizer drill

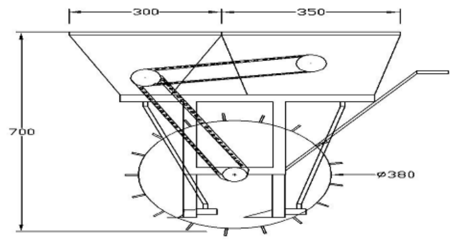

Figure 10. Side view of developed bullock drawn dry paddy seed cum fertilizer drill

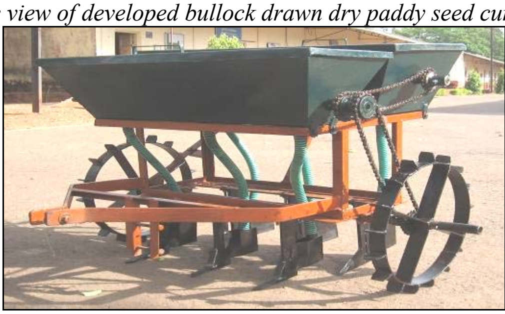

Figure 11. Developed bullock drawn dry paddy seed cum fertilizer drill

Frame. The frame of the 3 row seed cum fertilizer drill was made of MS angle of 25×25×5 mm with a square cross section. Provision was made to adjust the spacing between two furrow openers. An adjustable hitch is fabricated having 3 point converging link. It gives ease of attachment and adjustment, uniform depth and stability to the developed bullock drawn dry paddy seed cum fertilizer drill.

RESULTS AND DISCUSSION

The influence of selected variables on operation efficiency, number of seeds per hill, missed hills seed spacing and design concepts of components are discussed. Seed properties are important for optimizing the parameters of the seed drill. Based on the geometrical parameters of the seed, the cup design for metering mechanism was decided. Long and bold variety of paddy was selected for testing the uniformity of seeding and for field performance.

Table 1. Detail specification of developed prototype of bullock drawn dry paddy seed cum fertilizer drill

No.	Components	Specification	Material
1	Ground wheel	Rim diameter: 380 mm, rim width: 40 mm	MS flat40×5 mm
2	Seed box	Trapezoidal shape cross section, height of box 220 mm, upper side 750×350 mm, bottom side 600×250 mm, angle of inclination of 63° with the horizontal, 3 no. 1 for each furrow opener	16 SWG MS sheet
3	Fertilizer box	Trapezoidal shape cross section, height of box 220 mm, upper side 750×300 mm, bottom side 600×100 mm, angle of inclination of 60° with the horizontal, 3 no. 1 for each furrow opener	16 SWG MS sheet
4	Seed metering mechanism	Cup feed metering mechanism, diameter of seed plate 200 mm, 8 cups around the periphery, distance between cups 150 mm.	14 SWG MS sheet
5	Fertilizer metering mechanism	Adjustable orifice type, ribbed rubber 100 mm dia., sliding plate 600×5 mm with holes 5 to 15 mm.	16 SWG MS sheet, MS flat 25×5 mm
6	Clutch	Dog clutch, length of handle 1100 mm	MS flat25x3 mm
7	Power trans-mission unit	Sprocket 19 teeth 60 mm dia., chain pitch 12.9 mm, total chain length 1879 mm.	
8	Main frame	Total length of 2800 mm	MS angle 25×25×5 mm
9	Furrow openers a. Shoe type b. Shovel type	Adjustable row to row spacing between 150 250mm Shoe type: height of shank 200 mm, C.S.A 1800 mm^2, rake angle 33°. Shovel type: height of shank 200 mm, length of shovel 100 mm	Medium carbon steel
10	Seed delivery tube	Diameter 25 mm, thickness 2 mm	Polythene tube

The average geometrical parameters of long and bold variety which was observed were 9.03, 2.97, and 2.13 of length, breadth and thickness respectively. The size, surface area and sphericity were 3.91, 56.73 mm^2 and 0.43 respectively. The mean thousand grain weight and angle of repose of all the varieties of paddy were observed as 23.58 g and 27° respectively. The bulk density of fertilizer was 1.079 g·cc^{-1}. The angle of repose of fertilizer was measured as 30°. Hence the slope of the seed hopper was designed as per the angle of repose of paddy which is 27° for free flow of the seeds from hopper. The slope of fertilizer hopper was 30° with the vertical. The hopper capacity for seed and fertilizer is 20 kg and 16 kg respectively. Fertilizer hopper is placed at the front side of the frame and the seed hopper is mounted behind it. Cup feed metering mechanism is used for seed as there is no any mechanical damage to seeds due to mechanical handling. The diameter of seed plate is 20 cm with 8 cups are mounted along the periphery of the seed plate. The seed rate can be varied between between 60 to 65 kg·h^{-1}.

An adjustable type metering mechanism is used for fertilizer. By adjusting the holes, the fertilizer rate can be varied in between 100 to 105 kg·h^{-1}. The metering mechanism is actuated by the ground wheel which transmits power by means of chain and sprocket. A clutch is provided to the ground wheel, so that the power is cutoff from the metering mechanism during turning. Polythene tubes of 25 mm diameter and 2 mm thick are used to convey seed and fertilizer from orifice to furrow opener by gravity. Furrow openers are used to place the seed at the desired depth. A shoe type furrow opener with the rake angle of 33° is used to place the seed at a depth of 3 to 5 cm. For placing fertilizer, a narrow pointed shovel type furrow opener is used for placing fertilizer at a depth of 5 cm. A provision is made to change the row to row spacing by adjusting the hole drill on the frame. Row to row spacing can varied between 15-25 cm. An adjustable hitch is fabricated having 3 point converging link. It gives ease of attachment and adjustment, uniform depth and stability to the developed bullock drawn dry paddy seed cum fertilizer drill.

CONCLUSIONS

The developed dry paddy seed cum fertilizer drill has worked satisfactorily in the field. The average theoretical field capacity, effective field capacity and field efficiency was 0.151 ha·h^{-1}, 0.11 ha·h^{-1} and 75.96% respectively. The developed bullock drawn seed cum fertilizer drill was found effective for direct sowing of dry paddy in the Konkan region for upland paddy cultivation. The performance evaluation of seed cum fertilizer drill was satisfactory for working in the well prepared seed bed. An average size of bullock can meet the draft. The average wheel slip was found within the limit. The percentage of missing hills was higher than the requirements. The actual field capacity and the field efficiency were found satisfactory.

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RAZVOJ ZAPREŽNE SEJALICE SA ULAGAČEM ĐUBRIVA ZA SETVU PIRINČA

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Sažetak: Predstavljen je razvoj zaprežne sejalice sa ulagačem đubriva za brdske terene, na osnovu fizičkih osobina semena. Boksovi za seme i đubrivo su trapeznog oblika, za slobodan tok materijala bez zagušenja. Mehanizam sa šoljama za doziranje semena je izabran zato što ne oštećuje seme i ne utiče na klijavost. Za doziranje đubriva ugrađen je mehanizam sa podesivim otvorima. Tokom okreta se pogon kvačilom odvaja od mernog mehanizma. Za otvaranje brazdice i ulaganje semena i đubriva su upotrebljeni podrivači sa ulagačkim motičicama. Međuredno rastojanje se može podešavati prema potrebama. Srednji teorijski poljski kapacitet, stvarni poljski kapacitet i radni učinak su iznosili 0.151 $ha \cdot h^{-1}$, 0.11 $ha \cdot h^{-1}$ i 75.96%, redom.

Ključne reči: *brdski tereni, poljski kapacitet, efikasnost*

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