Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2020; 9(1): 562-567
Received: 02-11-2019
Accepted: 05-12-2019

Manisha Sahu
Department of Farm Machinery and Power Engineering, Pt. SKS, CARS, Rajnandgaon, IGKV, Raipur, Chhattisgarh, India

Ajay Verma
Department of Farm Machinery and Power Engineering, Pt. SKS, CARS, Rajnandgaon, IGKV, Raipur, Chhattisgarh, India

VM Victor
Department of Farm Machinery and Power Engineering, Pt. SKS, CARS, Rajnandgaon, IGKV, Raipur, Chhattisgarh, India

Sunil Agrawal
Department of Agronomy, COA, IGKV, Raipur, Chhattisgarh, India

Corresponding Author:
Manisha Sahu
Department of Farm Machinery and Power Engineering, Pt. SKS, CARS, Rajnandgaon, IGKV, Raipur, Chhattisgarh, India

Design and development of tractor drawn FYM applicator cum planter

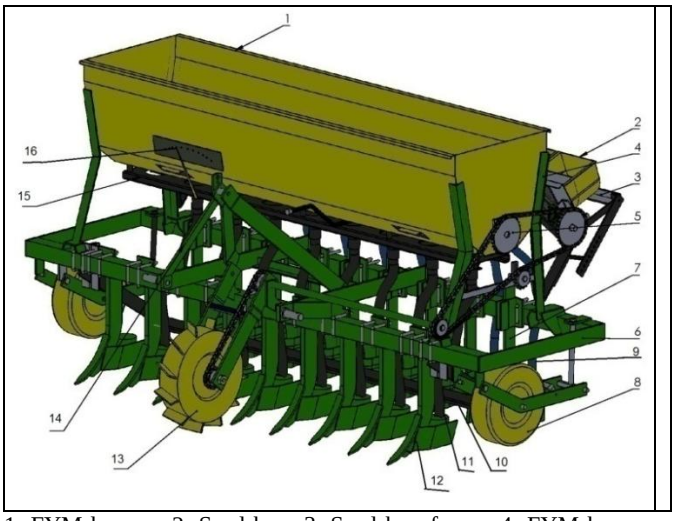
Manisha Sahu, Ajay Verma, VM Victor and Sunil Agrawal

Abstract
Tractor drawn FYM applicator cum planter was designed in Solid-works and fabricated at the National Agro Manufacturing Company, Ludhiyana and modified on the basis of laboratory test/field test in the workshop of Department of FMPE, SVCAET&RS, FAE, IGKV, Raipur. In the first phase a frame for FYM hopper was fabricated according to giving the desired capacity of FYM hopper. Nine orifice openings for FYM delivery was provided at bottom surface of hopper. A counter shaft was fixed which takes drive from ground wheel and rotates agitator. An agitator type feeding mechanism for FYM and inclined metering unit for seeds was provided. The FYM metering mechanism has speed reduction from main axle shaft to agitator shaft was 1:0.6 ratio. The FYM agitating shaft had 28, 33 and 49 RPM at tractor forward speed of 2, 4 and 6 km/h, respectively. These speeds were sufficient to break the clod of FYM.

Keywords: Agitator, FYM hopper, orifice opening, Seed metering unit

Introduction
Farmyard manure is an excellent and valuable source of nutrients for agricultural soil crop system. Accurate and controlled application of farmyard manure improves the nutrient use efficiency of the soil. Other advantages are to lower production cost while improving crop yields and soil quality. Applying the manure in controlled way also decreases odor and greenhouse gas emissions. Properly designed farmyard manure applicators can provide more flexibility to the users by allowing the control of application rate of FYM that are adapted to the specific needs of the soils and crops.
The equipment for the application of solid, semi-solid manure and other organic materials discharge the products at varying rate depending upon ground and PTO speeds of tractors, equipment settings and manure moisture content (Barrington *et al*., 1997) [2] and Lague *et al*., 1994) [8]. This equipment is calibrated during normal manure application times and recalibrated whenever a new source of manure with different moisture content is applied (Cemagref, 1997) [4]. Manual spreading of solid and semi-solid manure are strenuous and satisfactory uniformity is still difficult to obtain.
Sowing of crops is the further next operation in the field of broadcasted FYM which added extra cost and energy whereas resulted in reduced crop yield, returns and wastage of FYM in excess amount. A machine of this type did not exist. So a prototype FYM applicator cum planter for farmyard manure was designed and fabricated in 2018. This article details its design and construction. The specific test objectives were to design the FYM application unit and develop the unit.

Materials and Methods
The tractor drawn FYM applicator cum planter was designed in Solid-works and fabricated at the National Agro Manufacturing Company, Ludhiyana and modified on the basis of laboratory test / field test in the workshop of Department of FMPE, SVCAET & RS, FAE, IGKV, Raipur (Fig.1). The physical properties i.e. bulk density, moisture content, dry matter content, angle of repose and angle of friction of FYM, rice and chickpea were studied and measured.



1. FYM hopper, 2. Seed box, 3. Seed box frame, 4. FYM hopper frame, 5.Power transmission system, 6. Main frame, 7. Inverted 'T' type furrow opener (for seed), 8. Gauge wheel, 9.Seed delivery tube, 10. Planker (double angle iron), 11. FYM delivery tube, 12. Shovel type furrow opener (for FYM), 13. Drive wheel, 14. Three point hitch link, 15. Funnel plate, 16. Orifice opening position indicator.

Fig 1: Tractor drawn FYM applicator cum planter

Design of FYM applicator orifice opening

Number of orifice was depends on total number of furrow openers in the frame. Spacing between furrow openers was 225 cm. Dimensions of orifice opening was depend on requirement of FYM application rate and delivery rate at given forward speed. FYM delivery rate can be determined by the following formula:

$$AR = \frac{Q \times 10{,}000}{W \times V} \qquad (1)$$

Where, AR is the application rate (2000) kg/ha, Q is manure delivery rate (4.38) kg/sec, W is actual width of application (2.03) m, V is forward travel speed (1.08) m/sec. Beverloo *et al.*, (1961) developed an equation for flow of solids. The equation was given as:

$$Q = 35\, w \sqrt{g}\, (B - 1.4d)^{2.5} \qquad (2)$$

Where, Q is the rate of flow (43.8), g/s, w = is bulk density (0.43), g/cm^3, g is gravitational constant (981), cm/s^2, d is average screen size of particles (3.7), cm, B is the width of opening of orifice, cm.

FYM Applicator /hopper

The shape of frame was considered trapezoidal in order to make easy movement of material inside it. Reddy *et al*. (2013) [10] provided the trapezoidal shape of manure box (Fig.2). Bulk density of FYM was determined as 420 kg/m^3. Volume and capacity of FYM hopper was designed by following formula:

$$V = \frac{Q}{\rho} \qquad (3)$$

Where, V = volume of box, m^3, ρ = bulk density of material, kg/m^3, Q = box capacity, kg.

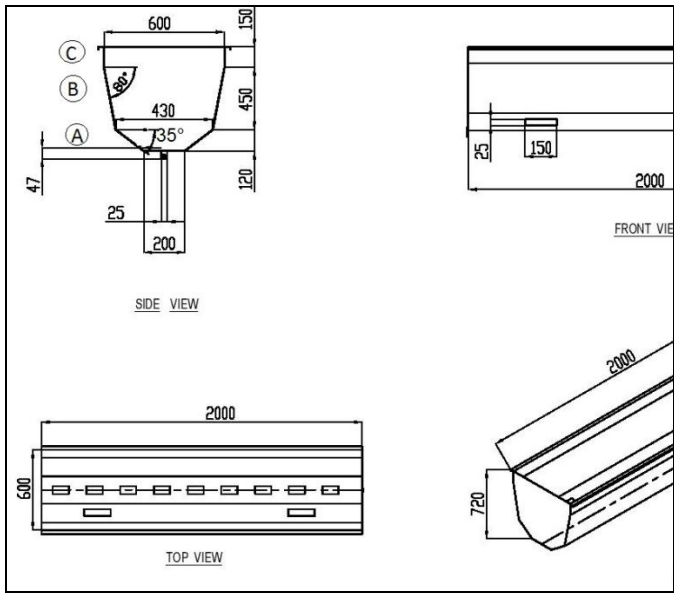


Fig 2: FYM hopper

Seed box

Individual seed box was developed for each inclined plate type seed metering mechanism for nine rows. Recommended seed rate for rice was 8 to 30 kg/ha sowing with planter at different spacing. These seed rate was divided by the number of furrow openers. The agronomical requirement for chickpea seed for SCI (Sustainable Chickpea Intensification) method include seed rate 40.51 kg/ha, row spacing as 50 cm, plant to plant spacing as 20 cm.

Thickness of FYM hopper and seed box

The thickness of FYM hopper and seed box was calculated by using following formula (Sharma and Mukesh, 2008) [12];

$$t_s = \sqrt[3]{\frac{3 \times \rho \times a^2 \times h^2}{4 \times a \times b_s}} \qquad (4)$$

Where, t_s is thickness of FYM hopper and seed box in cm, ρ is bulk density in kg/cm^3, a is bottom width of FYM hopper and seed box in cm, h is height of FYM hopper and seed box in cm, b_s = bending stress in kg/cm^2 (Let b_s= 1000kg/cm^2).

Inclined plate metering mechanism for seed

An inclined plate was developed based on the design procedure adopted by Ryu and Kim (1998) [11] and Ahmadi *et al* (2008) [1]. Five design variables shown in Fig.3 are defined and used to determine the exact size of the groove. Dg was the depth of the groove should be slightly larger than the length of seed, 9 mm and 15 mm for rice and chickpea, respectively. Wg indicate the opening of the groove periphery of plate should be slightly larger than the length of seed, 9 mm and 12 mm for rice and chickpea, respectively. θg denotes the opening angle of groove is defined as an angle between the two straight lines connecting the starting and final points of the groove and the centre of the plate, respectively. It determines the loading process of the groove, 8° for both rice and chickpea metering plate. βrs was taken 60° which is the right side angle of the groove determines the ease in loading process of the groove. Rc denotes radius of the curvature of groove bottom which was taken as 2.0. Round groove bottom prevents seeds or other substances from clinging to the bottom.

Plate of diameter 170 mm was fabricated for the inclined plate mechanism for metering of seeds. The depth of the groove was selected on the basis of greatest dimension measured for rice seeds. It was observed that the geometric mean diameters of the rice and chickpea seeds were 3.47 mm and 7.20 mm, respectively. These values were shows that the rice seeds were cylindrical in shape and chickpea seeds were near around circle.

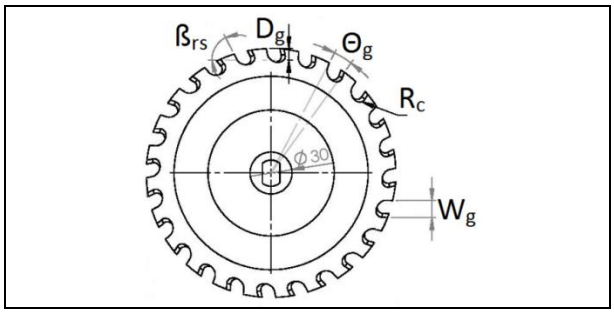


Fig 3: View of seed metering plate showing different variables

Power transmission for metering unit

1. For FYM discharge unit

Drive for the FYM discharge unit was taken from ground wheel. For rotating agitator, chain and sprocket assembly an arrangement has been made for power transmission (Reddy *et al.* 2013) [10]. Sprocket of FYM discharge shaft had 30 teeth (S4) as shown in Fig. 4. When the tractor forward speed was 2 km/h then it was changed into m/s and got 0.55 m/s. Diameter of ground wheel was taken 380 mm. Perimeter of ground wheel was calculated as 1.19 m. Therefore, ground wheel revolution N_1 was found 28 RPM, while the speed ratio between ground wheel sprocket S1 and agitator shaft sprocket S4 was 1:0.6. Hence, the agitator shaft rpm N_4 was 18. Further tractor forward speed 4 km/h and 6 km/h were used to calculate the agitator rpm as above procedure. However, the FYM agitating shaft had 33 and 49 RPM at tractor forward speed of 4 and 6 km/h, respectively as shown in Table 1.

Table 1: Rotation of agitator shaft per minute

Speed ratio	Speeds	Speed, km/h		
		2	4	6
	Speed, m/s	0.55	1.08	1.62
N1=1.0	Drive wheel, RPM	28	55	82
N4=0.6	Agitator shaft, RPM	18	33	49

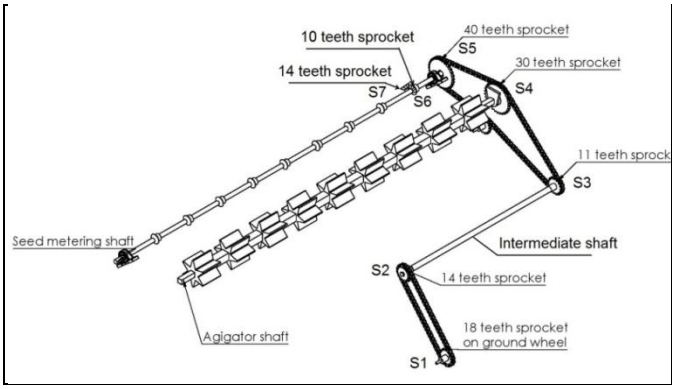


Fig 4: Power transmission unit, Variable Sprocket for seed metering unit was (S5)

2. For seed metering unit

Selection of pulley is given by the following formula (Khurmi and Gupta, 1987) [7].

$$N_1 \ T_1 = N_2 \ T_2 \qquad (5)$$

Where

N_1 , T_1 = Number of revolution and number of teeth driving sprocket, respectively.

N_2 , T_2 = Number of revolution and number of teeth driven sprocket, respectively.

N_7, T_7 = Number of revolution and number of teeth on bevel gear of seed metering plate, respectively.

$$N_7 = 1.28 \ N_1$$

The sprockets were selected based on the speed reduction of the inclined plate. An eighteen teeth chain sprocket was used at ground wheel to transmit power to fourteen teeth sprocket on the first shaft and this shaft has another sprocket having 11 teeth. The power from the first shaft was transmitted to FYM metering shaft through a 30 teeth sprocket. From the FYM metering shaft, the power was distributed to the seed metering shaft having a set of sprockets were provided for changing the speed ratios to change the seed spacing and seed rate for rice and chickpea.

Development of prototype

Development of machine components was based on the principles of operations. The mechanical details were also given which indicate adequate functional rigidity of the developed machine.

Main frame

The whole assembly was mounted on frame. It was provided with an arrangement to fix the FYM hopper, seed hopper, power transmission mechanism and furrow openers. Total height of machine from ground was 1350 mm, this height facilitate for easy loading of FYM in the hoper suggested by Lokhande (2012) [9] and Chase (2010) [5].

Furrow opener for FYM and seed

Nine number of shovel type furrow openers were used to open the soil for placement of FYM in band form. The FYM conveyed through funnel tubes from metering mechanism to the furrow opener and dropped behind the shoe in the opened furrows. Nine number of inverted "T" type furrow openers were used to open for placement of the seeds. The seeds were conveyed through cone tubes from metering mechanism to the furrow opener and dropped behind the shoe in the opened furrows.

Agitator (FYM metering unit)

The agitator was developed as the rotating device. It was used as effective way to move a wide variety of materials. Gravity flow with agitation of FYM above an adjustable orifice opening, principle used for FYM applicator for farmyard manure. An agitator is a mechanism which rotates inside the FYM hopper (Wilhoit *et al*. 1994) [13]. The agitator was designed by considering the parameters like, diameter of shaft, length of shaft, number of M.S. plates, length and width of M.S. plates, the height of each plate from surface of shaft, angle between two plates etc. Speed of rotation of agitator was 0.6 times of the ground wheel. The agitator breaks down of manure clods at the impact velocity of 0.2 to 1.5 m/s.

Drive wheel

The FYM agitating unit and seed metering unit were get the power from drive wheel. Power was transmitted through the

chain and sprocket mechanism. Apart from that they also helped in balancing, minimizing the vibrations and controlling the depth of planting. To overcome the problem of traction on soft beds, the front roller was provided with pegs.

Slider plate
Sliding plate is mainly used for adjustment of opening area in the manure box (Reddy *et al*., 2013) [10]. Slider plate was provided in the machine to control the flow of FYM inside the funnel.

Funnel plate
Funnel plate was provided to the applicator to deliver the flow of FYM from orifice to the FYM tube. Total nine numbers of funnel were provided on the funnel plate. Funnel was designed on the basis of angle of repose of FYM.

FYM delivery tube and seed delivery tube
The FYM delivery tube was provided at the outlet of the funnel. These are detachable parts of the implement. It was a flexible PVC pipe. Seed was delivered in furrow opener through the seed delivery tube. Seed tube angle was 30° rearward from vertical. Improved uniformity has been obtained in tests with plate type planters by angling the seed tube rearward 15 to 30° from the vertical by Kepner *et al*. (1987) [6].

Gauge wheel
The width of gauge wheel was selected as 100 mm. The prototype two gauge wheels were made of MS sheet of thickness 3 mm. They helped in balancing, minimizing the vibrations and controlling the depth of planting has the machine.

Planker
Deposition of FYM with soil in the field is very important operation to reduce the nitrogen loss in the form of ammonia. Double angle iron was attached just behind the shovel type FYM furrow opener.

Three point hitch link
Three point hitch link was used to connect the machine with the tractor through three point hitching system.

Result and Discussion

Design of FYM applicator orifice opening
Orifice opening was made just below the agitator on the FYM bottom surface. The length of orifice was taken 50 mm and the total width was 72 mm as shown in Fig.5. Total four number of openings was given to the orifice by sliding the slider plate (Table 2).

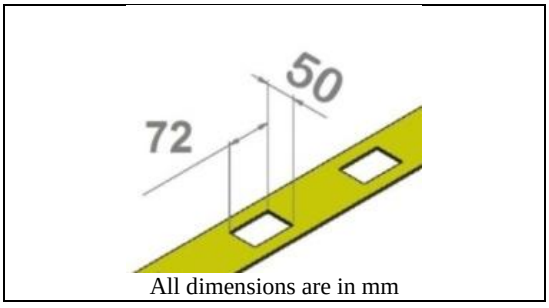


Fig 5: View of orifice opening

Table 2: Specification of orifice

Opening position of orifice	Size of opening, mm
1/4th	18
1/2nd	36
3/4th	54
Full	72

FYM applicator hopper
FYM hopper was divided in two sections. Rectangular in shape at top and trapezoidal at bottom. Angle of repose was taken 35° for designing of hopper to facilitate ease of FYM sliding. Overall dimensions of FYM hopper was 2000 mm × 600 mm × 720 mm as length, width and height, respectively. Total volume of FYM hopper was 0.71 m^3 and the capacity was found 302 kg.

Seed box
The seed box was rectangular in shape with semi circular bottom made up with GI (Galvanized Iron) sheet. Volume of seed box was 0.01 m^3. Capacity of seed box was 5 kg and 7 kg for rice and chickpea, respectively. Total nine seed box was attached on seed box frame. Length, width and height of seed box were 240 mm × 220 mm × 200 mm, respectively.

Thickness of FYM hopper and seed box
The thickness of sheet of FYM hopper and seed box was determined as 3 mm and 2 mm, respectively.

Inclined plate metering mechanism
Depth and width of metering cell for rice was 9 mm, respectively. However, for chickpea seeds the depth and width of cell was 15 and 12 mm, respectively. It was observed during testing that inclined metering plate cell for rice successfully accommodate two to three seeds whereas the cell of chickpea plate accommodate only one seed.

Power transmission system

1. For FYM discharge unit
The agitator makes 18, 33 and 49 rpm at machine speed of 2, 4 and 6 km/h, respectively. These speeds of agitator rpm were sufficient to break and mix the manure.

2. For seed metering unit
Sprocket (S5) was used for rotating the seed metering shaft. This seed metering shaft had different number of sprocket to obtain different seed spacing. At a time only one sprocket was attached in place of (S5) to obtain desired seed spacing. Seed metering plate for rice have 24 number of cell and for chickpea it has 12 number of cell. Four sprockets having number of teeth 40, 30, 20 and 10 gave the seed spacing of 20 cm, 15 cm, 10 cm and 5 cm, respectively for rice and 30, 25 and 20 numbers of teeth of sprocket gave the seed spacing 30 cm, 25 cm and 20 cm, respectively for chickpea.

Development of prototype

Main frame
Frame of applicator cum planter has to be rigid and strong. It was made by joining two angle iron of mild steel of size 60 mm× 60 mm × 5 mm. The total length, width and thickness of frame was 2415 mm × 685 mm × 60 mm, respectively as shown in Fig. 4.19 which provide sufficient strength and space to carry whole assembly or component of applicator and planter mounted on it.

Furrow opener for FYM and seed

Length and width of shovel was 185 and 40 mm, respectively. Shovels were connected to the tines of size 500 mm × 90 mm ×10 mm as length, width and thickness, respectively. Square braces of size 90 mm were used to connect the FYM furrow opener to the frame. Connection of braces to the frame was done by U shape clamp type screw. The dimension of overall length, width and thickness of FYM furrow opener was 550 mm × 50 mm × 10 mm, respectively. Length and width of inverted T type furrow opener was 185 and 90 mm, respectively.

Agitator metering mechanism

Agitator was used for agitating and meters the FYM and their dimensions were 116 mm length and 145 mm diameter. Agitator had six projections plate which were arranged in circular pattern 60° to each other as shown in Fig.6. It mixes and breaks the large particles of FYM for easily expelled out through. The agitator shaft was square in shape having 25 mm side's dimension. Two continuous agitators were set at the difference of 30° angle between their M.S. plates.

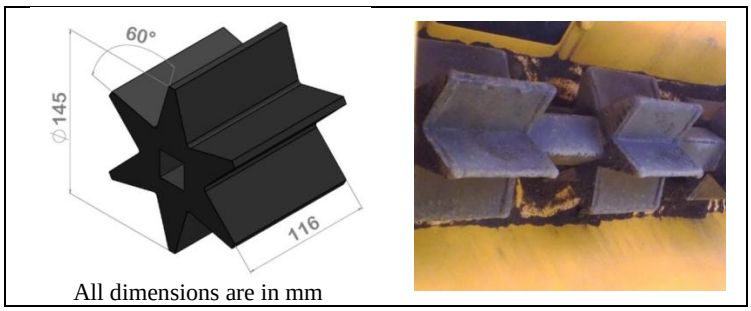


Fig 6: View of Agitator (FYM metering unit)

Drive wheel

Drive wheel was made by MS sheet. Diameter and width of drive wheel were 380 mm and 100 mm, respectively. Drive wheel had 12 numbers of pegs around the periphery to generate better traction on the field. These pegs were mounted on periphery of drive wheel made of MS sheet of 5 mm thickness having dimensions length and width was 90 mm x 40 mm, respectively with an angle of 25° with the horizontal plane (Fig.7).

Slider plates

Fully opening position of orifice was 72 mm, therefore slider plate can cover and uncovers gap of 72 mm. It was fabricated by G. I. sheet. Length, width and thickness of slider plate were 1885 mm, 100 mm and 5 mm, respectively (Fig.8). Slider plate was slide by the help of lever welded at the end of slider plate for adjusting opening of orifice.

Funnel plate

Diameter of funnel on top and bottom were 100 mm and 40 mm, respectively. Total length, width and thickness of funnel plate were 1910 mm × 175 mm × 5 mm, respectively (Fig.9). Angle between top and bottom portion of funnel was 35°.

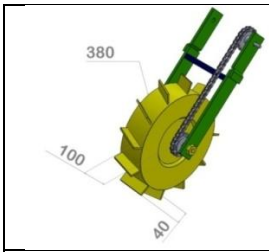


Fig 7: Drive wheel

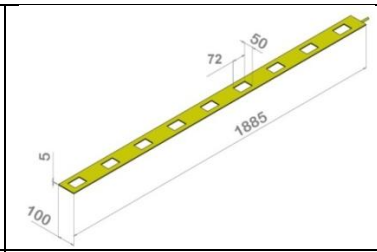


Fig 8: Slider plates

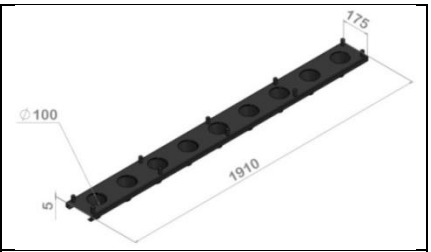


Fig 9: Funnel for FYM

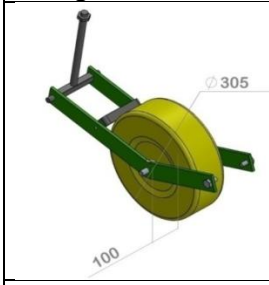


Fig 10: Gauge wheel

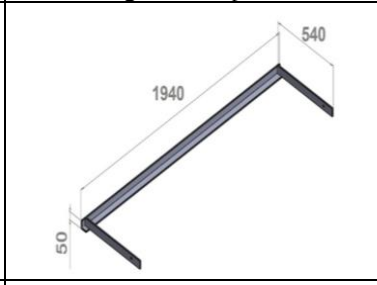


Fig 11: Planker

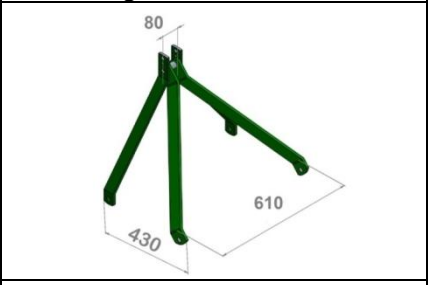


Fig 12: Hitching system

FYM delivery tube and seed delivery tube

PVC pipe of diameter 50 mm and 25 mm has been used as a delivery tube for FYM and seed, respectively.

Gauge wheel

Diameter and width of gauge wheel were 305 mm and 100 mm, respectively (Fig.10). Screw mechanism was provided on gauge wheel to control the depth of application.

Planker

Box section of MS angle iron was used as planker for incorporate the FYM with in the soil. The position of box section was just behind the FYM furrow opener. The overall dimension length, width and thickness of planker were 1940 mm × 540 mm × 50 mm (Fig.11).

Hitching system

Hitching system was made of MS flat. Top link hole had the size of 25.5 mm. Hole size of lower link was 28.7 mm. Lower hitch spacing was 870 mm (Fig.12).

Conclusion

FYM can be used as commercial fertilizer applied in band with sowing operation. This technology can reduce the cost and gave better yield with soil improvement. Environment can be saved from harmful chemical by using farmyard manure. Proper facility to manage the solid manure has the demand of manure applicator. Therefore FYM applicator cum planter was designed and developed which can apply FYM in band form with their surface incorporation in soil with planting operation in present research work.

References

1. Ahmadi E, Ghassemzadeh HR, Moghaddam M, Kim KU. Development of precision seed drill for oilseed rape. Turk J. Agric. For. 2008; 32:451-58.
2. Barrington S, Lague C, Masse D, Cote D, Fortier M. Manure: a valuable resource that can be managed. Proceeding of the conference and 21st Symposium sur les bobine latiters. Quebec. 1997, 93-128.
3. Beverloo WA, Leniger A, Velde JV. The flow of granular solids through orifices. Chemical engineering science. 1961; 15(3-4):260-269.
4. Cemagref. Fertilizing and crop protection equipment. Cemagref-Dicova/Federation Nationale des CUMA/ITCF/Lavoiser Tech & Dic. Paris, France. 1997, 136-169.
5. Chase GG. Solid notes, the University of Akron. 2010; 10:1-26.
6. Kepner RA, Bainer Roy, Barger EL. Principles of Farm Machinery. 1987, 234-235.
7. Khurmi RS, Gupta JK. A text book of Machine Design. S Chand. 1987, 356-357.
8. Lague C, Roy PM, Chenard L, Lagace R. Wide span boom for band spreading of liquid manure. Applied Engineering in Agriculture. 1994; 10(6):759-763.
9. Lokhande PS. Development of tractor operated farm yard manure (FYM) applicator. Published thesis, JAU, Junagarh, 2012.
10. Reddy MC, Veerangouda M, Yarnal RS. Development of animal operated farm yard manure applicator. International Journal of Agricultural Engineering. 2013; 6(2):519-523.
11. Ryu HI, Kim KU. Design of roller type metering device for precision planting. Transactions of ASAE. 41:923-30.
12. Sharma DN, Mukesh S. Farm Power and Machinery Management (Principles and Practices). Jain Brothers. 1998; (1).
13. Wilhoit JH, Bannon JS, Duffield RR, Ling Q. Development and evaluation of a drop applicator for poultry litter. Transactions of the ASAE. 1994; 10(6):777-782.