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DESIGN, DEVELOPMENT AND EVALUATION OF FERTILIZER ATTACHMENT TO THE TRACTOR DRAWN SEED DRILL

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Abstract: The National Seed Project in the University of Agricultural Sciences, Bengaluru has imported the tractor drawn seed drill for sowing bold seeds (pulses, peas etc.) under the foreign exchange programme. The Department of Agricultural Engineering in the University of Agricultural Sciences, Bengaluru, has suitably modified the imported seed drill for sowing small seeds like finger millets. In this seed drill only seeds can be sown and the placement of fertilizer is done separately by broad casting manually. In the broad casting process, the fertilizer use efficiency of the plants is very less and the most of the fertilizer applied to the soil by broadcasting is taken away by the weeds. The right placement of seed and fertilizer helps in achieving better yields which are directly affected by healthy germination, crop stand and plant population. Placement of fertilizer is very essential for optimum utilization. An attempt has been made in this study to develop a fertilizer attachment to the imported seed drill to drop the seeds and fertilizer simultaneously at a desired rate and at a desired depth.

The fertilizer box designed and developed was mounted to the frame of the existing seed drill with the support of angle iron frame. The agitator was provided in the fertilizer box to break the formation of bridge of fertilizer in the openings provided to drop the fertilizer. The transparent tubes were connected between the fertilizer box and the furrow openers to facilitate the operator to check the continuous flow of fertilizer. The power to drive the fertilizer metering mechanism and the agitator was taken from the ground driving wheel. When the driving wheel rotates during operation the metering rollers and fertilizer agitators mounted over a common shaft rotates. Provision has been made to drop the fertilizer as per the recommendations per unit area depending upon the crop required. The performance of seed cum fertilizer drill was evaluated by adopting RNAM (Regional Network for Agricultural Machinery) test codes and found working satisfactorily.

Keywords: Seed cum fertilizer drill, Metering mechanism, Ground wheel, Agitator Fertilizer box

I INTRODUCTION

India has made spectacular progress in agricultural production. The country recorded an all time high production of 242 million tons of food grains in 2010 as against 55 million tons in 1950-51. Prior to 1960, the traditional methods followed for sowing of seeds are hand broad casting, opening furrows by wooden plough and dropping seeds by hand in the furrows or dropping seeds in the furrows through the bamboo tube attached to the wooden plough. These methods did not uniformly distribute or accurately place the seeds at the desired depth leading to reduced plant population and hence results in poor yield. Placement of seeds at correct depth is very important for proper germination of the seeds especially under Dryland farming where soil moisture is at greater depth. Similarly, placement of fertilizer is also very important for maximum fertilizer utilization efficiency of the plants. The fertilizer should not cum in contact with the seed at the time of germination to avoid chemical injury on the seed. The right placement of seed and fertilizer helps in achieving better yields which are directly affected by healthy germination, crop stand and plant population. Therefore precision placement of seeds and fertilizer in the soil is necessary for achieving perfect standing of crop.

Experiments conducted by various Research Institutions shows that fertilizer placement in the soil should be 2.5 cm to the side of the seed and 2.5 cm below the seed for effective utilization of fertilizers. Although a few imported tractor-driven seed cum fertilizer drills could be found in India particularly at Government and Big private farms in early 1960's, the research and development (R&D) efforts to modify the imported seed-cum-fertilizer drills suited to Indian conditions are started in 1960's onwards. In the beginning manually metering three row seed-cum-fertilizer drill attachment was developed to the wooden cultivator. It is a simple device for line sowing of seeds and placement of fertilizers through a bamboo tube with a bowl attached to a wooden cultivator.

This simple device is adopted in many parts of India. However, the accuracy in dropping of seeds and fertilizers in this seed-cum-fertilizer drill depends on the skill and experience of the operator. To improve further, manual metering of seeds and fertilizers has been replaced by mechanical metering. At present several designs of mechanically metered 3 to 5 rows of tractor driven seed drills and seed–cum–fertilizer drills have been designed and adopted in the country for sowing variety of crops In the power driven seed drills seed metering are done by fluted-feed rollers or by gravity with an adjustable opening by agitator in the form of rubber rollers or flaps for which power is taken from ground wheel. In seed-cum-fertilizer drills granular fertilizers are metered by gravity with an adjustable opening by agitator and powdered fertilizers by spur wheel. Use of agitator prevents from bridging of seeds / fertilizer over the openings and to ensure uniform flow. Seeds and fertilizer are dropped through the transparent plastic tubes in the furrows opened by the furrow openers. Use of transparent plastic tubes helps in detecting the clogging of the seeds or fertilizers and also to avoid corrosion. Keeping these facts in view a fertilizer attachment was developed to the tractor drawn imported seed drill and its performance was evaluated. Adopting the seed cum fertilizer drill, the fertilizer use efficiency by the plants can be increased with reduction in man power required to broadcast the fertilizer and substantially reduce in production cost.

II REVIEW OF LITERATURE

Line sowing is the most efficient means of sowing the crops and most ideal for crop management (Devnani, 1989). Line sowing facilitates manual and mechanical weeding between rows, optimum plant population with reduced seed rate than broadcasting. Line sowing also facilitates maximum tillering and better sunlight penetration for healthy growth of plants. Sharma and Bansal (1980) reported 19.10 per cent increase in wheat yield by line sowing using seed-cum-fertilizer drill. Sharma et al. (1983) developed a single row seed-cum-fertilizer drill with a combined furrow opener for seed and fertilizer. Sowing of gram by this seed-cum-fertilizer gave better germination with increase of 20 per cent yield. Adoption of seed-cum-fertilizer drills facilitate dropping of seeds below the soil, reduces man power and seeds required and increase fertilizer use efficiency and substantially reduce in the production cost (Astu and Gupta, 1994, Kaleemullah et al., 1997 and Ajay Kumar Verma and Dewangan, 2007).

III MATERIALS AND METHODS

The design of fertilizer attachment to the tractor drawn imported seed drill consists of the main frame, fertilizer box, agitators, fluted roller type metering mechanism and plastic transparent tubes. The specifications of the fertilizer attachment developed to the six row seed drill are shown in Fig.1 and the department components of the seed cum fertilizer labeled are shown in Fig.2

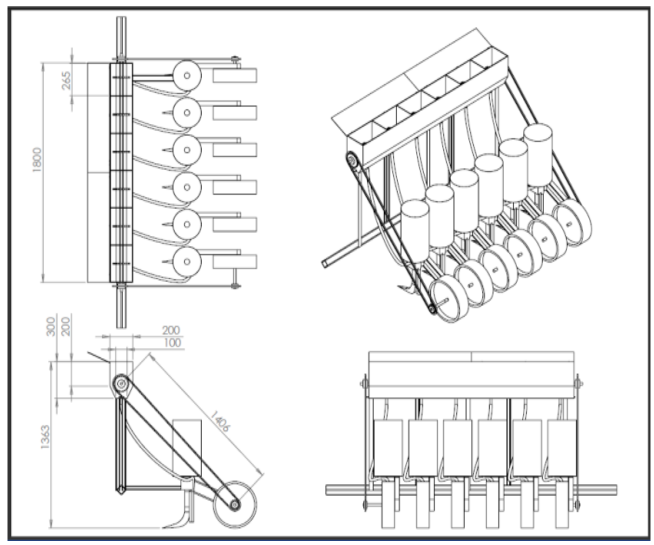

Figure 1: Dimensions of seed cum fertilizer drill

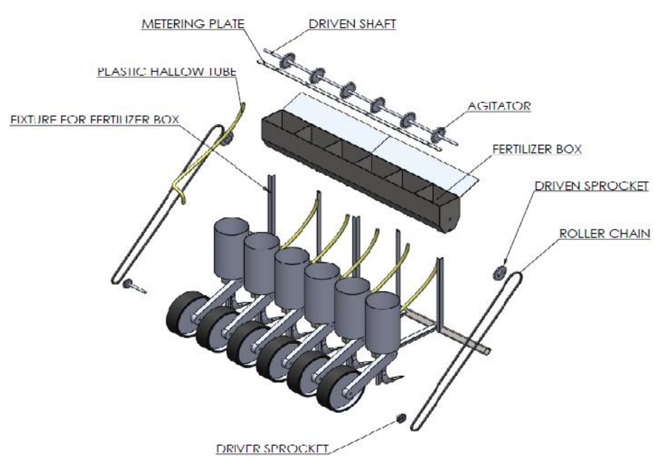

Figure 2: Components of seed cum fertilizer drill

Here seed metering is performed by the rotation of ground wheel through gear wheel mechanism. Fertilizer metering is done by motion given by the ground wheel to the shaft which is present inside the fertilizer box through chain sprocket arrangement. Power is transmitted from the ground wheel to pick up the chamber shaft by means of chain and sprocket system. The number of teeth in the driving shaft main sprocket is 25 where as the number of teeth in the sprocket of the pickup chamber shaft is 15, so as to maintain plant to plant distance of 30 cm. The fertilizer box is directly mounted over the main shaft. Fertilizers fall by gravity through circular holes of 20 mm diameter at the bottom of the fertilizer hopper. The rate of fertilizer fall is controlled by the adjustment of hole size. Agitators are provided on the main shaft to facilitate easy flow of fertilizer.

3.1 Design details

Roller chain: Roller Chain has been selected, because roller chain by nature of its design is capable of transmitting high loads and provides the ideal drive media for the connection of slow to medium speed shafts located on extended centers.

Table 1 : Summary of Advantage

Summary of Advantages

FEATURES	GEARS	ROPE	BELT	CHAIN
Efficiency	A	X	B	A
Positive drive	A	X	B	A
Center distance	C	A	B	A
Elasticity	C	A	A	B
Wear resistance	A	C	B	A
No pre-load	A	C	C	A
Multiple drives	C	X	C	A
Heat resistant	B	B	C	A
Chemical resistant	B	A	C	A
Oil resistant	A	A	C	A
Adaptations	C	B	C	A
Power range	A	X	B	A
Ease of maintenance	C	B	B	A
Standardized	C	B	B	A
Environment	A	A	C	A

A = Excellent
B = Good
C = Poor
X = Not appropriate

3.2 Calculation of sprocket dimensions:

The dimensions of standard sprockets and other general sprockets are calculated as follows. At first, the diameters of Sprockets are calculated from the following calculation formulas. Calculation formulas of tooth gap forms are shown

Table 2: Formula

Item	Formula
Pitch diameter (Dp)	$Dp = \frac{P}{\sin\frac{180°}{N}}$ P: Chain pitch N: Number of sprocket teeth
Standard tip diameter (Do)	$Do = P\left(0.6 + \cot\frac{180°}{N}\right)$
Root diameter (D_B)	$D_B = Dp - Dr$ Dr: Roller outer diameter
Caliper diameter (Dc)	Even-numbered teeth $Dc = D_B$ Odd-numbered teeth $Dc = Dp\cos\frac{90°}{N} - Dr = P\frac{1}{2\sin\frac{180°}{2N}} - Dr$
Maximum hub diameter and maximum groove diameter (D_H)	$D_H = P\left(\cot\frac{180°}{N} - 1\right) - 0.76$

Item	Formula
Tooth width (T)	Single strand T=0.93W−0.15 Double or triple strands T=0.90W−0.15 Four or more strands T=0.86W−0.30 W: Inner width of chain
Transverse pitch (C)	C=W+ (4.22×Plate thickness)
Total tooth width (M)	M=C (Number of chain rows−1)+T
Tooth face radius (Rc)	Rc≒1.063P (Minimum value)
Center position of Rc (h)	h≒0.5P P: Chain pitch
Depth of face (groove) from pitch line to maximum hub diameter (Q)	Q≒0.5P

3.3 Calculation formulas for tooth gap forms:

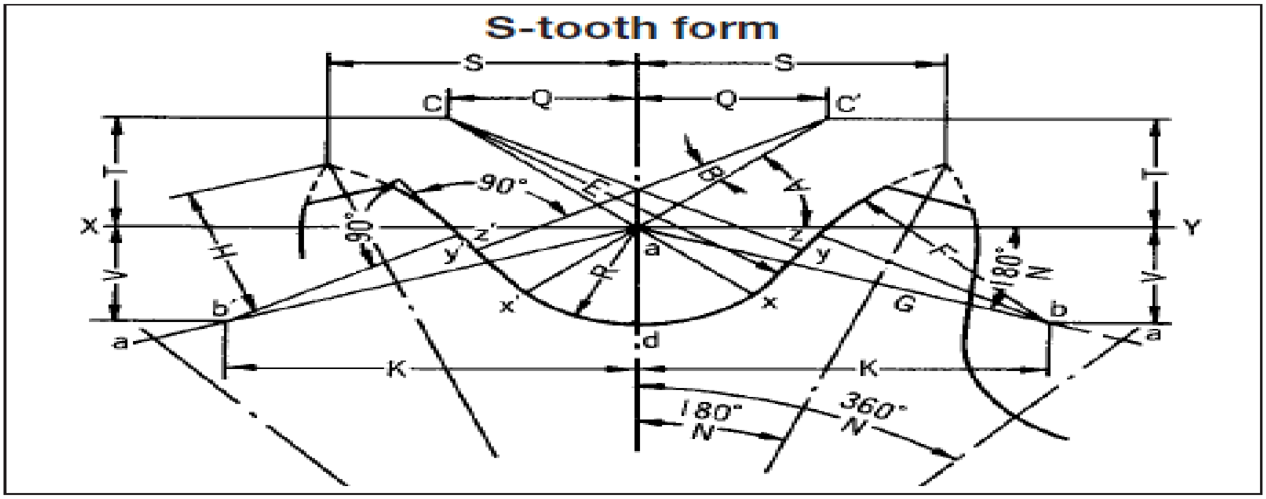

Figure 3 Tooth gap form

As the most rational tooth gap forms in which the pressure angle changes in response to the elongation of a smoothly rotated roller chain with the lapse of service time, ANSI specify two types of tooth profiles: U-type and S-type. In general, S-type tooth profiles are adopted in accordance with ANSI, and our standard sprockets also have S-tooth profiles.

Table 3: Formula

Item	Formula	Item	Formula
Ds (Tooth arc diameter)	$Ds=2R=1.055Dr+0.076$ Dr: Roller diameter	G	$G=ab=1.4Dr$ Point b is on the line drawn from point a on line xy at an angle of 180°/N. (With U-tooth form, aa' is parallel to chordal pitch line e-e.)
R	$R=0.5025Dr+0.038$	K	$K=1.4Dr\cos\frac{180^\circ}{N}$
U (Pitch clearance)	$U=0.07\ (P-Dr)\ +0.051$ (S-tooth form: U=0) P: Chain pitch	V	$V=1.4Dr\sin\frac{180^\circ}{N}$
A	$A=35^\circ+\frac{60^\circ}{N}$ N: Number of teeth	F	$F=Dr\{0.8\cos\left(18^\circ-\frac{56^\circ}{N}\right)+1.4\cos\left(17^\circ-\frac{64^\circ}{N}\right)-1.3025\}-0.038$
B	$B=18^\circ-\frac{56^\circ}{N}$	H	$H=\sqrt{F^2-\left(1.4Dr-\frac{Pt}{2}+\frac{U}{2}\cos\frac{180^\circ}{N}\right)^2}+\frac{U}{2}\sin\frac{180^\circ}{N}$ Pt= Chordal pitch equal to chain pitch $=P\ (1+\frac{Ds-Dr}{Dp})$ (S-tooth form:a-a, U-tooth form:e-e)
ac	$ac=0.8Dr$	S	$S=\frac{Pt}{2}\cos\frac{180^\circ}{N}+H\sin\frac{180^\circ}{N}$
Q	$Q=0.8Dr\cos\left(35^\circ+\frac{60^\circ}{N}\right)$	Approximate outer diameter of sprocket	Approximate outer diameter of sprocket (at J=0.3p) $=Pt\left(0.6+\cot\frac{180^\circ}{N}\right)$
T	$T=0.8Dr\sin\left(35^\circ+\frac{60^\circ}{N}\right)$	Outer diameter of sprocket when sprocket tooth heads are sharp	Outer diameter of sprocket with sharp tooth head (at J=H) $=Pt\cot\frac{180^\circ}{N}+2H$ (In this case, generally this formula is corrected to obtain the outer diameter.)
E	$E=cy=1.3025Dr+0.038$	Maximum pressure angle	Maximum pressure angle $=xab=35^\circ-\frac{120^\circ}{N}$ (Pressure angle in the case of a new chain)
$\overline{xy}$	$\overline{xy}=(2.605Dr+0.076)\sin\left(9^\circ-\frac{28^\circ}{N}\right)$	Minimum pressure angle	Minimum pressure angle $=xab-B=17^\circ-\frac{64^\circ}{N}$
yz	$yz=Dr\{1.4\sin\left(17^\circ-\frac{64^\circ}{N}\right)-0.8\sin\left(18^\circ-\frac{56^\circ}{N}\right)\}$	Average pressure angle	Average pressure angle $=26^\circ-\frac{92^\circ}{N}$

Volume of fertilizer box

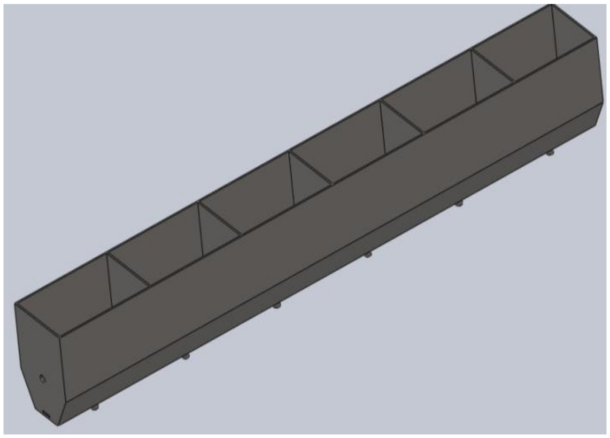

Figure 4: Fertilizer box

Here we split the box as square and trapezium for calculations.

For square section volume $V_1 = l * b * h$

$V_1 = 20 * 30 * 20$

$V_1 = 12000\ cm^3$

For trapezium section volume $V_2 = h\ [(A_1 + A_2)/2]$

$V_2 = 10\ [(20+10)/2]$

$V_2 = 150\ cm^3$

Total volume $V = V_1 + V_2$

$V = 12000 + 150$

$V = 12150\ cm^3$

There are six boxes, so $V = 12150 * 6$

$V = 72900\ cm^3$

Here we using fertilizer which has a density 75 pounds/acre, for 75 pounds/acre the conversion factor is 0.87

1 pound = 0.4536 kg

75 pound = 75 * 0.436

= 34.02 kg

1 $feet^3 = 28317\ cm^3$

75 $pounds/feet^3 = (75 * 0.4536)/28317$

$= 1.20 * 10^{-3}\ kg/cm^3$

Conversion factor for 75 pounds/acre is 0.87

75 $pounds/feet^3 = (75 * 0.87 * 0.4536)/28317$

= (29.597/28317)

$= 1.045 * 10^{-3}\ kg/cm^3$

For each box $= 12150 * 1.045 * 10^{-3}$

= 12.69 kg

For 6 box = 12.69 * 6

= 76.18 ~ 77 kg

View of the modified seed cum fertilizer drill.

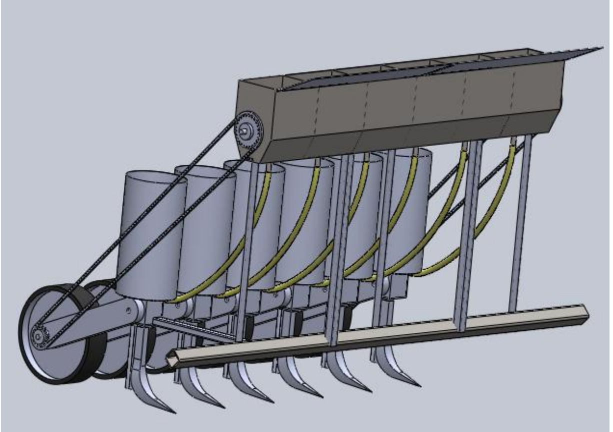

Figure 5 :Seed cum fertilizer drill

IV CONCLUSION

The overall working width of the seed cum fertilizer drill is 1.8 m and it is operated by 35 hp tractor. There are six furrow openers; the distance between each furrow openers is 30 cm. The modified seed cum fertilizer drill has capability to make sharp turns and cross small bunds and easy to operate. The use of modified seed cum fertilizer drill is advantageous for Dryland agriculture for sowing seed and fertilizers at a desired rate and at a desired depth. This seed cum fertilizer drill saves time, money and also more area can be covered under favorable climatic condition to get higher yield.

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