International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-10 Issue-2, July 2021

"Design and Development of Tractor Drawn Subsurface Manure and Seed Applicator"

Abhishek Kumar, Jayant Singh

***Abstract:** Organic farming is now recognized as the best known alternative to the conventional agriculture, where cultivation and raising of crops and best quality of food is grown without any harm to the soil health, environmental and to the human being and microorganism present in the soil. Efficient organic nutrient supply to plant in adequate quantities to sustain most plant growth and yield while minimizing the environmental affected by the use of large quantities of inorganic fertilizers and pesticides which reduces the soil characteristics and productivity. Vermicom post is the major alternatives for organic farming with higher plant nutrients. Therefore, a tractor drawn subsurface manure and seed applicator was designed and developed in Farm Machinery and Power Engineering Department, G.B.P.U.A& T Pantnagar, Uttara khand for placement of vermicom post (organic manure) at a depth of 50 to 200 mm below the soil surface. Firstly the frame for vermicom post and seed hopper was fabricated according to the desired capacity of vermicom post manure hopper. Six rectangular orifices were provided for delivery of manure at the middle of the bottom surface of the manure hopper. A counter shaft was fixed on the frame which was driven by the ground wheel and rotated the horizontal screw conveyor shaft of the manure hopper as well as seed hopper shaft by means of chain - sprocket arrangement. The velocity ratios between the ground wheel and the manure and fluted roller shaft were 2:1. The manure hopper shaft and fluted roller shaft were rotated at 14, 35 and 41 rpm when tractor forward speed 2, 4 and 6 km/h, respectively. Two depth control side wheels were provided below the frame to adjust the depth of cut of machine in field operation. A furrow opener was designed to penetrate into the soil at the desired depth and placed the vermicom post and seed below the soil surface.*

***Keywords:** Vermicom Post, Placement Of Manure, Wheat, Screw Conveyor, Fluted Roller, Furrow Opener*

I. INTRODUCTION

The quantity of nutrients of organic manure required by the plants varies depending on plant characteristics (like crop, yield level, variety, planting rate), environmental conditions (like moisture and temperature), soil characteristics (soil properties, fertility), and soil and crop management.

Manuscript received on June 26, 2021.
Revised Manuscript received on July 03, 2021.
Manuscript published on July 30, 2021.
* Correspondence Author

Abhishek Kumar*, Ph.D Research Scholar, Farm Machinery and Power Engineering Department, G. B. Pant University of Agriculture and Technology, Pantnagar Uttarakhand, India. Email: abhishekranu2010@gmail.com

Dr. Jayant Singh, Professor, Farm Machinery and Power Engineering Department, G. B. Pant University of Agriculture and Technology, Pantnagar Uttarakhand, India. Email: jayantsingh07@gmail.com

Although these interacting factors affect plant nutrient uptake and recovery of applied nutrients, nutrient accumulation during the growing season generally follows plant growth. Since nutrients of soils are absorbed by roots. The roots must fully ability to exploit soil nutrients and water for optimum productivity. The present study was focused on designing a machine to subsurface application of vermicompost manure below the soil in the root zone of seed with accurate rate. Therefore a tractor drawn subsurface manure and seed applicator was designed in the farm machinery and power engineering department of GBPUA&T Pantnagar University to place the manure below the root zone of the seed so that the roots can uptake adequate amount of nutrients for growing stage. In India manure is applied using manual broadcasting method and bullocks carts resulting in increasing labour cost, more time consumption per unit area and loss of nutrients with poor application uniformity and wide variation in the application rate [15]. In view of the above, suitable technological mediation was needed for mechanization of manure application below the soil surface uniformly and in less time, therefore tractor drawn subsurface manure and seed applicator was developed.

II. MATERIALS AND METHODS

The following criteria were considered in designing of the subsurface manure and seed applicator (**Fig.1**) were (a) simplicity of fabrication (b) portability (c) cost of manure applicator and (d) cost of seed sowing. To design the manure and seed hopper and size of the applicator, physical as well as morphological parameters like length, breadth, thickness, bulk density, test weight and angle of repose of vermicompost and wheat seed were determined in the laboratory. UP2526 wheat variety was used during laboratory condition as well as field test condition.

III. DESIGN CONSIDERATION

Constructional descriptions of the subsurface manure applicator

The design of the subsurface manure and seed applicator (**Fig.2**) is so simple that it can be fabricated with locally available materials like mild steel sheet, mild steel beam (square section),angle iron (L-shape), roller chain, mild steel sprocket and nut bolt. The different functional parts of the machine were made with these materials: vermicompost and seed hopper, hub, ground wheel, main frame, furrow opener, shaft and supporting frame respectively and major specifications of developed machine are shown in Table 1.

Table 1.Major Specifications of prototype tractor drawn subsurface manure and seed applicator

Sl.No	Parameters	Material used	Values
1	Power source		35hp **(Tractor operated)**
2	Size (L×W×H)		2080 mm ×600 mm ×370 mm
3	Frame	Mild steel	Rectangular mild steel
4a	Type of furrow opener	Chilled steel/ high grade steel	T -type inverted furrow opener ,6 front & 2 rear, spaced 225 mm and provision for changing the row spacing.
4.b	boot	Carburized structural steel	
5	Seed metering device	Aluminum alloy	Fluted roller metering mechanism made of dye casted aluminum, no of flute=12
6	Manure metering screw and shaft	Plain carbon steel	Horizontal screw conveyor, Pitch of screw =150 mm, diameter of shaft, Ø =30 mm, screw diameter, Ø=105 mm
7	Power transmission	Mild steel	Roller chain and sprocket arrangement
8	Ground drive wheel	Mild steel	Front mounted floating type with lugs on its periphery, Diameter, Ø =380 mm
			Face width =78 mm, no of lugs= 10
			Height of lugs= 45 mm
			Lugs angle with horizontal = 35^0
9	Vermicompost and seed hopper	Mild steel	1800×270 mm and 1800×240 mm Capacity: 100 kg
10	Seed delivery pipe	PVC	Diameter, , Ø=25 mm
11	Vermicompost delivery pipe	Mild steel	Diameter, Ø = 70 mm and length= 610 mm
12	Counter shaft	Plain carbon steel	Diameter, Ø =25 mm
13	Seed rate of wheat		100-125 kg/ha
14	Speed of operation		2 to 6 km/h
15	Field capacity		0.7 ha/h
16	Overall weight of machine, kg		250

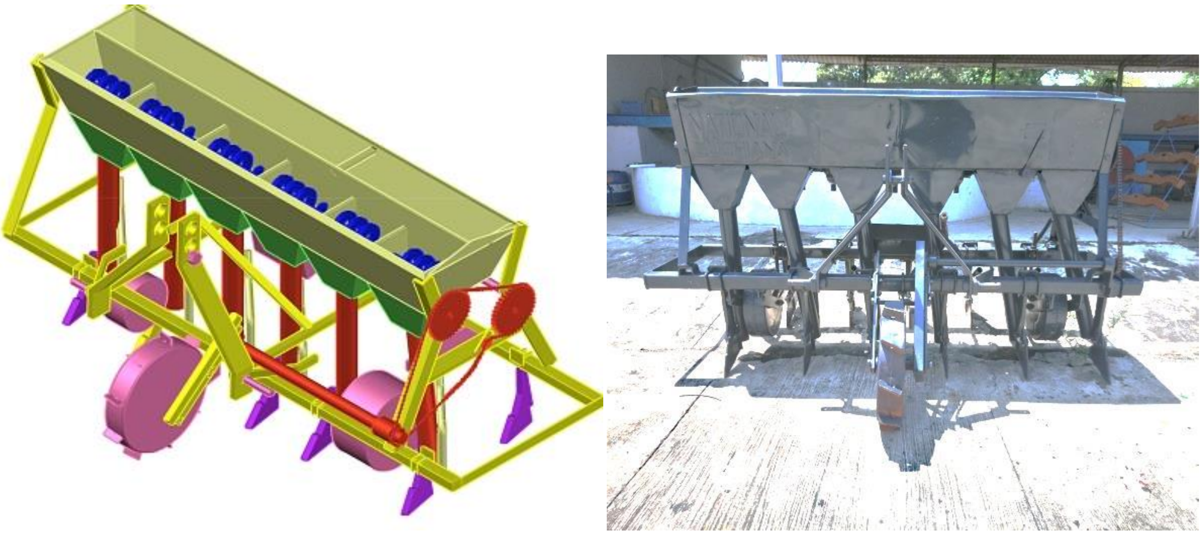

Fig.1. Isometric view of developed prototype subsurface manure and seed applicator

Retrieval Number: 100.1/ijrte.B61800710221
DOI: 10.35940/ijrte.B6180.0710221
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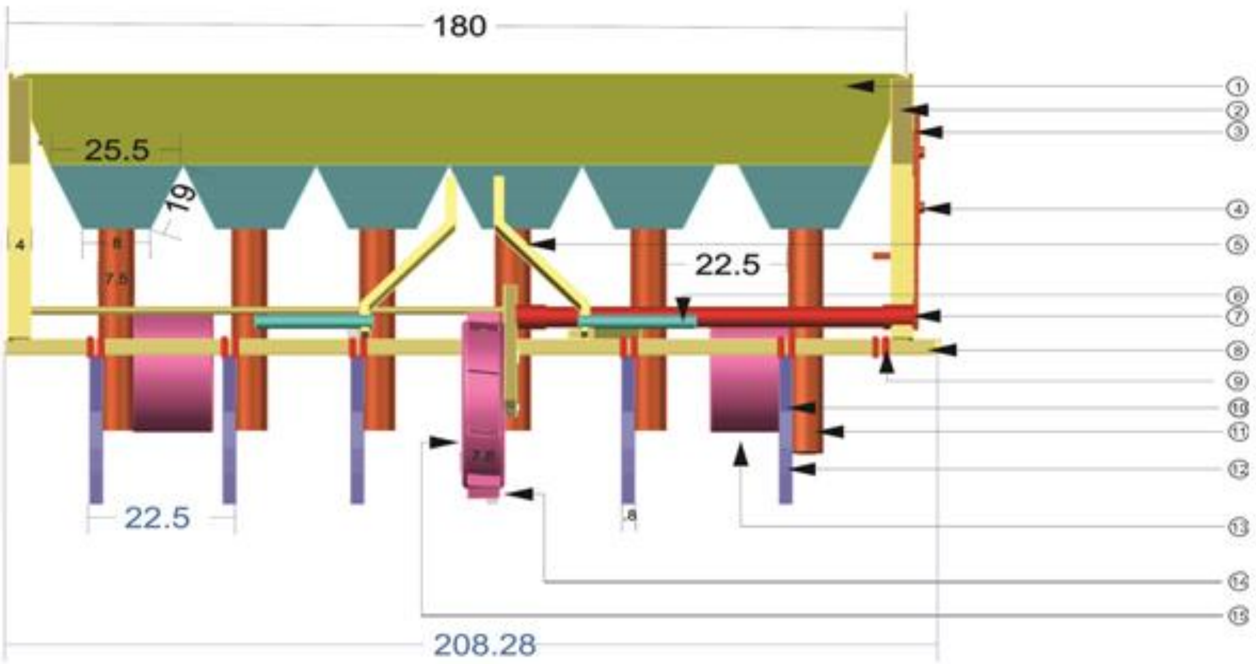

Fig.2. Front view of developed Prototype of Subsurface Manure and Seed Applicator

1.vermicompost hopper;**2**.hopper supporting stand;**3**.roller chain;**4**.sprocket;**5**.three point hitching system,**6**. hitch pin; **7**.intermediate shaft; **8**.frame; **9**.U clamp, **10**.standard; **11**. vermicompost delivery tube;**12**.furrow opener;**13**.depth control side wheel;**14**.lugs;**15**.ground wheel

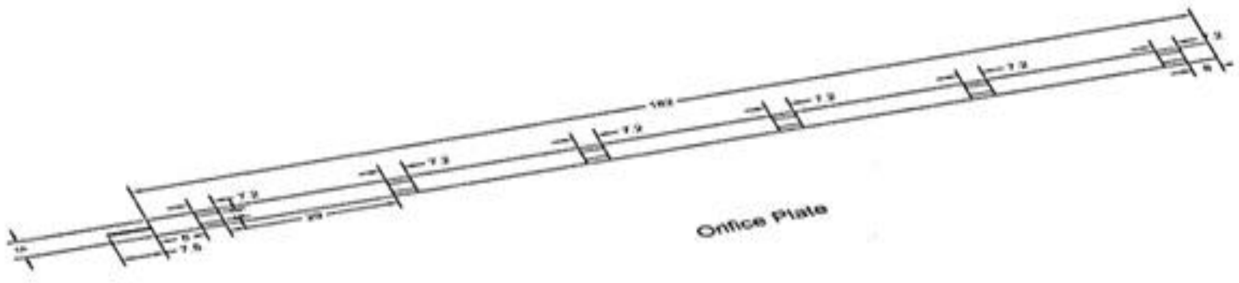

Fig.3.Orifice plate of manure hopper

Design of orifice plate of vermicompost hopper

Six rectangular shape orifices **Fig.3** of size (70×50 mm) were designed on surface of the orifice plate at equal distances to deliver a recommended quantity of vermicompost manure. The flow rate of the vermicompost manure was calculated by the equation given below. [3] developed an equation for flow of solid materials. The equation was given below.

$$Q = 35\rho\sqrt{g}(B - 1.4d)^{2.5} \qquad [1']$$

Where,

Q = rate of flow, g/s
ρ = bulk density, g/cm^3
g = acceleration due to gravity, cm/s^2 =981 cm/s^2
d = average size of screen particles, cm
B = orifice diameter, cm

Width of opening was designed on the basis of the total number of furrow opener attached with the main frame. Total six furrow openers were fabricated in the machine. The spacing between two furrow openers were kept 225 mm. Second parameter was the forward speed of the machine and the third parameter was the application rate of vermicompost manure. The actual application rate was determined by using the equation.

$$application\ rate = \frac{Q \times 10000}{b \times s} \qquad [2']$$

Where,

Q = rate of flow, g/s
b = actual width of application, m
s = forward speed of the tractor, ms^{-1}

Vermicom post Manure Hopper Design

There were two hoppers, one of which for manure storage and second for seed storage was provided on the subsurface manure applicator as shown in Fig.4. The capacity of the manure hopper and seed hopper were 50 kg with trapezoidal shape. Volume of manure hopper was determined on the basis of the amount of material to be filled in at a given bulk density [16].

The hopper was designed to sustain a 50 kg of vermicompost manure. The hopper wall angle was kept 45^0 i.e. higher than the angle of repose of vermicompost. The volume of vermicompost hopper was determined by the equation 3' given below.

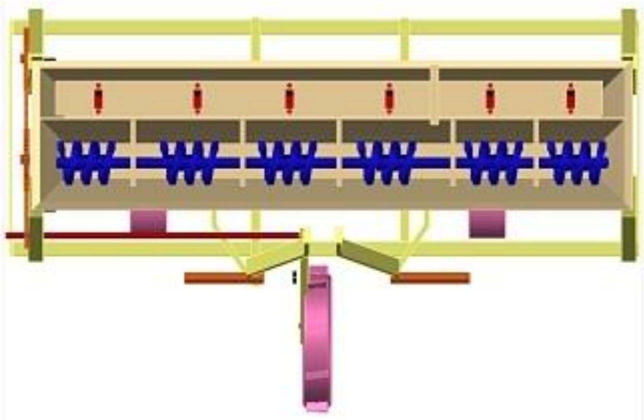

Figure 4 Top view of Prototype Machine

$$\rho = \frac{m}{V} \qquad [3']$$

Where,

ρ	=	bulk density of vermicompost, kgm^{-3}
m	=	weight of vermicompost, kg
V_v	=	Volume, m^3

$$605 = \frac{50}{V_v}$$

V_v=0.0826 m^3=0.09 m^3

Design of Seed Hopper

The seed hopper was made of mild steel sheet and was designed on the basis of the property of seeds **Fig.5**. The hopper was trapezoidal in shape. The seed hopper was designed to sustain 50 kg of seed at one time. The volume of the hopper was obtained using the expressions given by [9]. The angle of repose of wheat seed ranges from 23^0 to 28^0. The design of the seed hopper should be such that θ is more than 28^0 for easy flowing of seeds. The design of hopper was same as described earlier and found to be 0.126 m^3 repectively.

$$V_s = (a + h\cot\theta) \times h \times l_b \qquad [4']$$

Where,

l_b	=	length of seed hopper
a	=	bottom width of seed hopper
b	=	top width of seed hopper
h	=	height of seed hopper
θ	=	angle of repose of seed
V_s	=	Volume of seed box

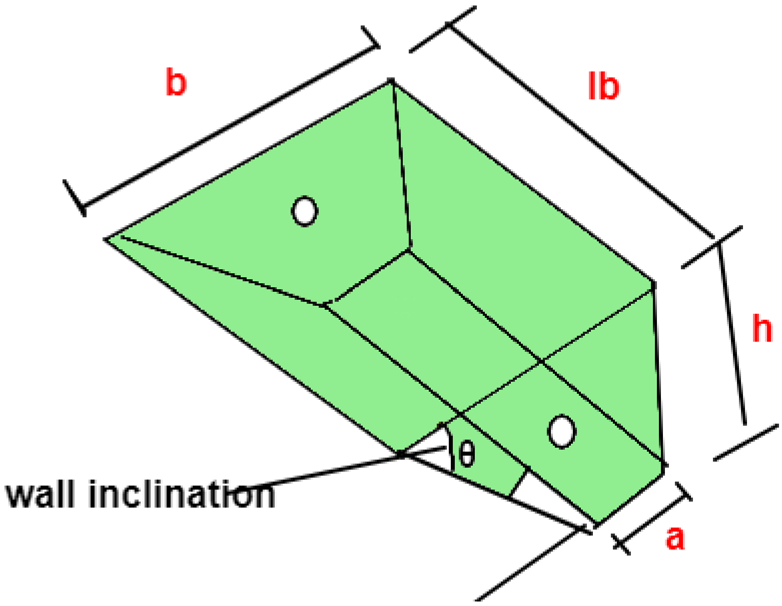

Fig.5.Isometric view of seed hopper

Design of Screw Conveyor Metering Mechanism

a. Design screw conveyor shaft

The shaft was considered to be subjected both bending and torsion moment. According [6] the failure of the shaft due to be in shear stress and the design considered this fact. Therefore, the solid shaft was selected made of plain carbon steel material AISI 1020 steel. The length and weight of the shaft were 1800 mm and 0.147 kN. The shaft was suspended between two bearings. The diameter of the shaft was determined by according to maximum shear stress theory by the equation 7'. The pulling force required to pull the machine was 136.91 N and the shaft was rotated at mean rotational velocity of 35 rpm when the forward speed of tractor was 4 km/h. Therefore power transmitted by the rotating shaft at 35 rpm was determined 0.152 kW by the equation given below.

Retrieval Number: 100.1/ijrte.B61800710221
DOI: 10.35940/ijrte.B6180.0710221
Journal Website: www.ijrte.org

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F = force required to pull machine, N
P = Power, kW
V = forward speed of machine, m/s
T = torque, N.m
d = diameter of shaft, mm
N = factor of safety, 2
σ_y = yield strength, 390 MPa
M = Bending moment, (wl/8), N.m (assume load is uniformly distributed)
w = weight of the shaft, 0.147kN

$$P = F.V \quad [5']$$

$$T = \frac{9550 \times kW}{rev/min} \quad [6']$$

Where,
According to maximum shear stress theory

$$d = \left(\frac{32 \times N}{\pi \sigma_y} \sqrt{4M^2 + 3T^2}\right)^{\frac{1}{3}} = 24.6 \text{ mm} \quad [7']$$

Hence the standard diameter of shaft was selected 30 mm for the design based on availability of material

b. Design of Metering System (screw conveyor)

The screw flight pitch and thickness of screw were decided on the basis of type of materials to be delivered. Therefore a single threaded screw of 3 mm thickness and pitch 150 mm was made on the solid shaft with an included angle of 29^0 [15]. The height and pitch diameter of threaded screw were determined as 97.45 mm and 2.57 mm. The conveying capacity for different combination [10] was calculated by using the equation 8’ given below.

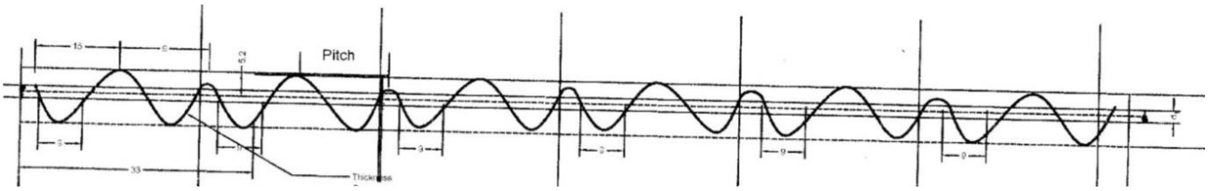

Fig.6. Single threaded screw conveyor mechanism for vermicompost delivery

$$C_s = 47.2\,(D_s^2 - d_s^2) \times p \times n \quad [8']$$

Where,
C_s = conveying capacity of screw conveyor, m^{3}h^{-1}
D_s = diameter of screw, m
d_s = diameter of shaft, m
p = pitch of screw conveyor, m
n = speed of conveyor, rpm

Determination of Thickness of Seed Hopper Sheet

The thickness of hopper sheet (t) was designed considering the maximum bending moment (BM_{max}) in the wall by the Rankine’s equation 9’ as 1904 kg-mm. Sheet thickness was found as 1.77 mm. However, for safer design and ease of availability, 2.5 mm thick MS sheet was selected. The seed hopper was also designed in similar manner.

$$BM_{max} = \frac{\rho h_3^2 b_2^2 \cos\theta}{8}$$

$$\sigma_{\max allow} = \frac{BM_{max} I}{y}$$

Where,
ρ = bulk density of the vermicompost manure, 605 kg/m^3
h_3 = maximum height of hopper, 0.37 m
b_2 = maximum width of hopper, 0.51m
BM_{max} = bending moment, kg.m
θ = angle of repose of vermicompost, 45^0
$\sigma_{\max allow}$ = maximum allowable shear stress,9.8 kg/mm^2
I = moment of inertia, mm^4
y = distance of the outer stress fiber from the neutral axis, t/2 mm

Design of Drive Wheel

Wheel was made of a mild steel sheet of thickness of 3 mm. The diameter of the ground wheel should be sufficient to cover the area in minimum time. The diameter of the ground wheel was 380 mm with a face width of 78 mm. Lugs were provided on the periphery of the wheel to improve the traction of the wheel and it also reduced the slip during operation in the field. The lugs were provided at a certain angle of 35^0 for self-cleaning in moist soil.

Design of Furrow Opener

Eight numbers of furrows openers fitted with 370 mm long shank, attached to fore bar of the frame, was fabricated to open furrow lines. The length, width, height of furrow opener was selected 200 mm, 10 mm and 3850 mm, respectively to obtain required width of the furrows. Inverted furrows with penetrated nose with rake angle of 20^0 from vertical and [9’] relief angle of 5^0 from the ground surface was kept for easily penetrated into the soil and for minimum draft force were fitted to form V-shape furrows. The furrow opener [10’] shank was designed by assuming maximum working depth of 150-200 mm. Since , the applicator would operate in well prepared soil, therefore, maximum draft force on furrow opener was 150 kgf/tyne was acted at a height of h/3 from the bottom surface of the furrow opener was obtained by the equation 11’.

$$a = \frac{h}{3} \quad [11']$$

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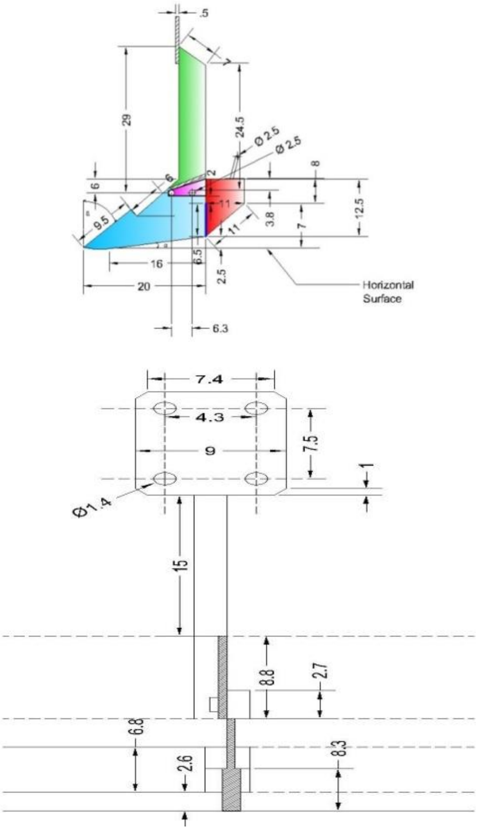

Fig.7. Side view and front view of designed inverted T-type furrow opener

Moment arm length = $(h' - a)$= 25.67 cm
Maximum bending moment in tyne =D$(h' - a)$= 377349 N-mm
Take factor of safety (f.o.s) = 2
Therefore, maximum bending moment in tyne= BM× $FOS = 754.698\ kN.mm$
The section modulus of the shank could be determined by using flexural equation.

$$M=\sigma_{max}Z \quad \textbf{[12']}$$

$$Z = \frac{\frac{bh^3}{12}}{\frac{h}{2}} = \frac{bh^2}{6} \quad \textbf{[13']}$$

Where,

I	=	moment of inertia of rectangular section
y_{max}	=	distance of the outermost layer from the neutral axis
M	=	bending moment, N.m
h'	=	total height of furrow opener, m
a	=	distance of draft force acting on furrow opener from surface, m
b	=	thickness of section, cm
h	=	width of the section, cm
σ_{max}		maximum allowable bending stress, 56 Nmm^{-2} for mild steel

Assuming h=4b and substituting in equation 13', thickness (b) and breadth (h) of shank was determined 17 mm and 68 mm respectively. Therefore, mild steel flat tyne of 68 ×17 mm size was selected for fabricating the shank of the furrow opener.

Seed Metering Mechanism

Design of fluted rollers

Fluted roller mechanism metering device was selected for placing of the wheat seeds into the furrow lines. The diameter and length of the roller was 47 mm and 50 mm and the diameter of flutes were made on the periphery of the roller was 9 mm. The roller was fitted into the ring and the whole assembly is called feed cup. The total numbers of flutes were twelve per roller and total six rollers were used in designed machine as shown in Fig.8. The space between the fluted roller and the feed cup was filled with seeds. At the base of the feed cup was a bottom plate, called flap, which was either propped up by a spring or made of spring steel. If the roller encounters a hard object, the flap was deflected and released it. The feed cup was provided with side walls. On one side of the feed roller was a plain feed cut off roller and on the other side was a ring covered inside which prevents the seeds from flowing out of the feed cup. The complete assembly was made of cast aluminum.

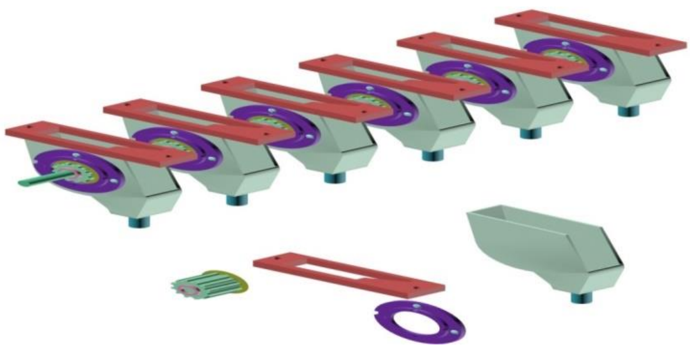

Fig.8. Fluted roller mechanisms for delivery of wheat seed

Depth control side wheels

Two depth control side wheels were mounted below the frame to control the depth of seeding during operation. It was made of mild steel sheet(closed type) having a diameter of 305 mm. with the help of depth adjusting screws, these wheels could be raised or lowered to increase or decrease the depth of seeding, respectively. The depth was adjusted 30 to 50 mm in wheat seeding.

Retrieval Number: 100.1/ijrte.B61800710221
DOI: 10.35940/ijrte.B6180.0710221
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Three Point Hitch Link

Three point hitch link **Fig.9** was used to connect the machine with the tractor through a three point hitching system. Mild steel sheet of size 510 mm ×45 mm× 8 mm was used. The overall dimensions length and thickness were 510 mm and 45 mm, respectively. Width varied front and back were 610 mm and 620 mm respectively.

Fig.9 Side and front view of three point hitching system

Main frame

Design of frame

A rectangular hollow frame of thickness 60 mm, overall length and width as 2080 mm and 600 mm was selected. The frame was designed considering it as a hollow beam with fixed ends and subjected to both bending and twisting moments. Maximum bending moment (M_1) at the center of the beam due to weight of 100 kg of wheat seed and vermicompost manure as shown in (figure 10a) was filled at a time in the hopper was determined as 441N.m by using the equation 14'.

$$M_1 = R_A \times \frac{L}{2} \qquad [14']$$

$$M_1 = 490 \times \frac{1.80}{2}$$

$$M_1 = 0.441\ kNm$$

Where,

M_1= bending moment, N-m
R_A= R_B = reaction at ends, 490 N and
L= length of beam, 1.80 m
Considering Fig.10b and assuming that all the 6 furrow openers are experiencing equal draft force of 1.47kN, therefore, reaction **(R_1 and R_2)** at the end of beam would be equal and was determined as:
R_1+ R_2 =6 ×1.47 kN =8.82 kN
By symmetry R_1= R_2 =4.41 kN
Therefore, maximum bending moment (M_2) due to draft force could be determined by taking moment at section x-x, as:.

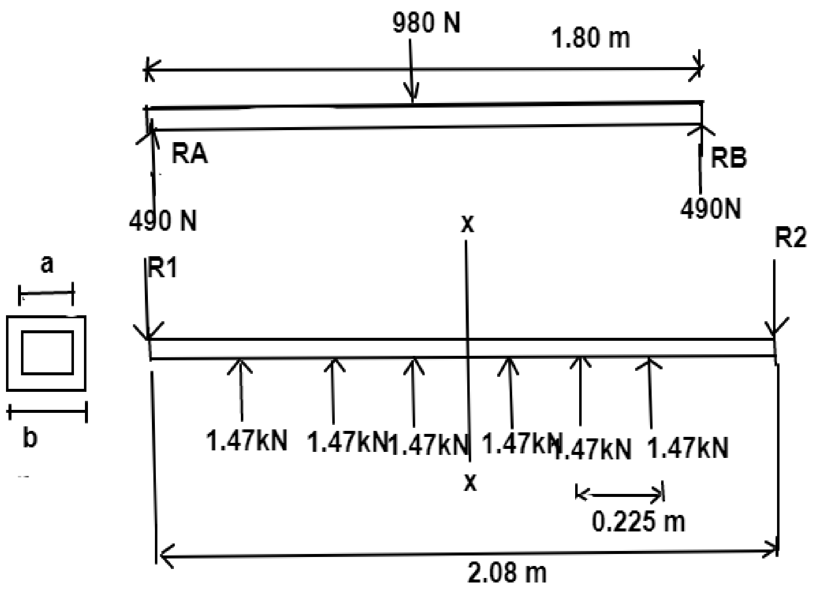

Fig.10a and 10b.Weight of wheat seed and vermicompost manure on the frame and draft force acting on forebar of the frame

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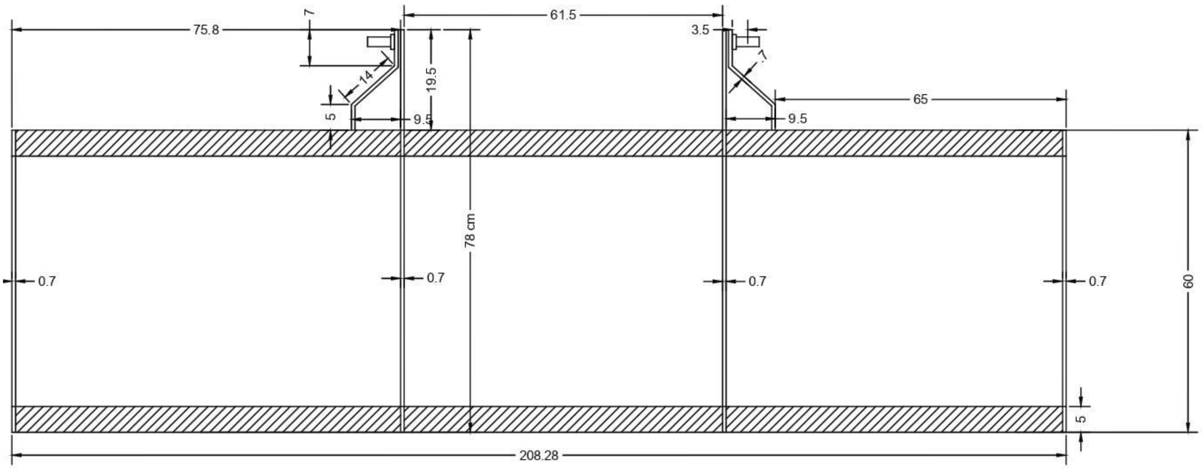

Fig.10c. Top view of the main frame

$$M_2 = R_1 \times (0.90) - 1.47 \times 0.562 - 1.47 \times 0.3375$$
$$- 1.47 \times 0.1125 = 2.481 kN.m$$

Therefore equivalent bending moment (M_b) would be determined as:

$$M_b = \sqrt{(0.441^2) + (2.481^2)} = 2.519 kN.m \quad [15']$$

Maximum torsional force (M_t) transferred on the beam due to draft force would be :

$$M_t = number\ of\ furrow\ openers$$
$$\times draft\ on\ each\ furrow\ opener$$
$$\times lever\ arm$$

$$M_t = 6 \times 1.47 \times 0.58 = 5.116\ kN - m$$

Considering maximum shear stress failure theory, the equivalent torsional moment (T_e) was determined as

$$T_e = \sqrt{(k_b M_b)^2 + (k_t M_t)^2} \quad [16']$$

$$T_e = \sqrt{(2 \times 2.519)^2 + (1.5 \times 5.1156)^2} = 9.17 kN.m$$

Where

T_e	=	equivalent torsional moment, kN.m
M_b	=	equivalent bending moment, 2.519kN.m
M_t	=	equivalent torsional moment, 5.1156 kN.m
k_b and k_t	=	shock and fatigue factors, 2 and 1.5

As the beam is subjected to stresses due to torsional moment, the maximum torsional shear stress was determined by the equation given below

$$\frac{\tau_{max}}{y} = \frac{T_e}{J} \quad [17']$$

$$\tau_{max} = \frac{T_e y}{J} = \frac{T_e}{Z} \quad [18']$$

$$Z = \frac{2}{9}\frac{\{a^4 - b^4\}}{a} = \frac{2}{9}\frac{\{(20+b)^4 - b^4\}}{20+b} \quad [19']$$

Where,

τ_{max}	=	designed stress of material ,Nm^{-2}
T_e	=	equivalent torsional moment, N-m
y	=	distance of edge from the center of the beam, a/2,m
J	=	polar moment of inertia of the cross section, m^4
Z	=	polar section modulus of hollow square section, m^3
a	=	inner length of rectangular section, m
b	=	outer length of rectangular section, m

$$\tau_{max} = \frac{S_y}{fos} = \frac{250}{1.2} \quad [20']$$
$$= 208.33\ MPa$$

$$\tau_{max} = \frac{T_e y}{J} = \frac{T_e}{Z} \quad [21']$$

$$208.33 = \frac{T_e}{Z}$$

$$208.33 = \frac{9\ kN - m}{\frac{2}{9}\frac{\{(20+b)^4 - b^4\}}{20+b}}$$

b=45 mm and a=b+2t=45+20=65 mm

τ_{max} was determined by equation 16' as 208.33 MPa by considering the allowable yield stress (S_y) for mild steel as 250 MPa and 1.2 as factor of safety (fos).Now substituting the values in equation 17' ,the value of outer and inner dimensions (a and b) of frame were determined as 45.53 and 35.53 mm respectively. However, standard size of hollow square pipe with outer and inner dimensions of 50 and 40 mm, respectively, having 5 mm thickness was selected for fabrication of the frame.

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Power Transmission System

The power transmission system was such that the power from the ground wheel transmitted equally to both of the metering mechanisms of vermicompost and seed respectively. Power transmission unit consists of a sprocket, roller chain (pitch=12.5 mm), idler and counter shaft. The ground wheel was fitted with 18 number of teeth sprocket (T1= 18) and the counter shaft consists of 14 teeth sprockets at both ends (T2=T3=14). The manure shaft consists of 37 teeth sprocket fitted at the end of the manure shaft (T4=T5= 37).

1. The speed reduction was provided in two stages, by chain and sprocket arrangement. Velocity ratios (VR) of the various stages were given in Table 3.
2. $N_1 T_1 = N_2 T_2$

Vermicompost Delivery Tube

An iron hollow rod of diameter of 70 mm and 610 mm was selected to deliver the vermicompost into the field.

Seed Delivery Tubes

PVC pipe was selected to drop the seed from the feed cup through the boot of the furrow opener into the soil. The pipe should be flexible and made of good plastic material to eliminate choking of seeds. The diameter of pipe was 25 mm respectively.

Depth Control Side Wheels

Two depth control side wheels were mounted below the frame to control the depth of seeding during operation. It was made of mild steel sheet(closed type) having a diameter of 305 mm. With the help of depth adjusting screws, these wheels could be raised or lowered to increase or decrease the depth of seeding, respectively. The depth was adjusted 30 to 50 mm in wheat seeding.

IV. RESULTS AND DISCUSSION

Physical Characteristics of Wheat Seeds

Physical characteristics of wheat seeds are given in **Table 2**.The shape of wheat seeds have oval faces. The average length, breadth, thickness and frontal area were found to be 5.693 mm, 2.379 mm, 1.619 mm and 21.50 mm^2 respectively. It was observed that bulk density, angle of repose and weight of thousand wheat seeds were 0.76 g/cc, 25^0 and 38 g respectively.

Table2. Physical characteristic of wheat seed (UP2526)

Sl.no	Parameters	Minimum	Maximum	Average
1	Length , mm	6.54	4.41	5.693
2	Breadth, mm	2.98	1.32	2.379
3	Thickness ,mm	2.40	1.01	1.619
4	Frontal area,mm^2	31.93	14.40	21.50
5	Weight of 1000 seeds, g	38		
6	Shape and size of seed	Oval shape		
7	Bulk density, kg/m^3	760		
8	Angle of repose, degree	23-28		
9	Moisture content,%	10		
10	Germination,%	85		
11	Variety	UP2526		

Design of the orifice plate of vermicompost hopper

Slider plate reduced or increased the cross section of the orifice openings thereby adjusted the application rate of vermicompost manure. Opening position of the slider plate controls the gravity flow of material from the hopper. Fully opening position of orifice was 70 mm, therefore the slider plate can cover and uncovers a gap of 70 mm as shown in **Fig.3**. It was fabricated by a Galvanized Iron sheet. Length, width and thickness of the slider plate were selected 1820 mm, 70 mm and 50 mm respectively.

Design of Vermicompost Hopper

The vermicompost hopper was made of mild steel sheet and divided into six sections and each section was trapezoidal in shape. Angle of repose was taken 43.3^0 for designing of hopper to facilitate ease flow of manure through it. The calculated dimension of the manure hopper was that the upper cross section area of the box was 1800×270 mm and the bottom cross section was 1800× 150 mm respectively and the distance between top and bottom cross section was 310 mm respectively.

Design of Seed Hopper

The seed box is trapezoidal in shape and made of Galvanized iron sheet. Capacity of the seed box was 50 kg respectively. The upper cross section of the box was 1800 × 240 mm and the bottom cross section was 1800 ×120 mm and the distance between them was 310 mm. respectively.

Screw Conveyor Metering System

The volume of material was conveyed by the screw conveyor at different rotation speeds viz 14, 35 and 41 rpm were found to be 0.870 m^3/h, 2.17 m^3/h and 2.54m^3/h respectively.

Thickness of Seed and Manure Box

The thickness of vermicompost and seed hopper was determined by the equation 9'. The thickness of sheet was estimated and found to be 2.5 mm respectively.

Drive Wheel

Drive wheel was made of mild steel sheet. Diameter of the ground wheel was 380 mm and the face width of the wheel was 78 mm, respectively. The lugs were made on the peripheral of the wheel to increase traction in the field. The number of lugs is about 10 and it was shown in Figure2.

Furrow Opener

The inverted T type furrow opener was selected and mounted on the frame of the applicator. There were 8 numbers of furrow openers clamped to the frame with the help of U clamp at 200 mm spacing, out of which six furrow openers were mounted in front of the frame and two furrow openers were mounted rear of the frame to balance the machine during field operation and . The length and width of the furrow opener were 185 mm and 90 mm and the height of the furrow opener was 370 mm respectively. This furrow opener developed a narrow furrow groove with reduced surface exposure and thereby helps to maintain humidity in a reasonably wet soil for better germination and emergence of seedlings.

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This furrow opener had adequate strength, toughness and hardness to work in uncultivated soil. The opener was consisted of the main plate, standard and boot. The main plate and standard was made **of high grade steel** whereas the boot was made of **carburized structural steel**. The front edge of the main plate might be given a hard coating surface or shot peening treatment to extend the service life.

Design of Fluted Roller

The fluted roller of 50 mm diameter with 12 flutes per roller, which was semicircular and each with a diameter of 9 mm ,would be able for metering the desired seeding rate of 100 $kgha^{-1}$ of wheat seed when the exposure length of the flute is approximately 27.85 mm. It was recommended that the dimensions of fluted roller should be accurately maintained so that inter row variation would be within ± 4% of the required seeding rate.

Design of radius of Curvature of Slot of Fluted Roller

The radius of curvature of the slot was obtained to be 6.235 mm.

Depth Control Side Wheels

Side wheel was used to control the depth of the subsurface manure and seed applicator. Diameter and width of the side control wheel were 305 mm and 100 mm, respectively. Screw mechanism was used for raising or lowering the weight of the machine by the rotation of screw downward or upward respectively. Two numbers of side wheels were provided on both sides of the machine to provide balance to the machine.

Three Point Hitch System

The three point hitching system is a standardized method of attaching implements to tractors. The developed machine was hitched to the tractor through the three point hitching system. The developed machine was raised upward or lowered downward by a tractor hydraulic system. The hitching system plates were made of mild steel flat plate. Top link hole diameter had the size of 25.5 mm and the diameter of hole at lower link was 28.7 mm respectively.

Power Transmission System

For Vermicompost Discharge Unit And Seed Metering Unit

The power transmission of developed machine was taken by the ground wheel which had the sprocket (T1) of 18 teeth had mounted on the hub of the wheel for transmitting the power to the intermediate shaft which had two sprockets of equal number of teeth viz 14 teeth's (T2=T3). The sprocket mounted on the manure and seed delivery shaft had equal size having number of teeth say (T4=T5= 37).The data was tabulated in Table 3 given below.

Table 3. Rotation speed of vermicompost manure shaft and seed metering unit shaft per minute

Transmission ratio	**speeds**		**Speeds(km/h)**	
		2	**4**	**6**
	Speed(m/s)	**0.55**	**1.08**	**1.66**
i_1= 1.0	N_1	28	56	83.47
i_2= 0.6	N_2=N_3	36	91.63	107.31
i_3= 2.6	N_4 =N_5	14	35	41

Vermicompost Delivery Tube

The vermicompost delivery tube of hollow cylindrical rod was made of mild steel and had been used for placement of manure. The length was 610 mm and the diameter of the tube was 70 mm respectively. The ground clearance of the pipe was kept 70 mm so that the pipe could not choke at working operation in the field.

Seed Delivery Tube

Poly vinyl chloride pipe of diameter 25 mm had been used as a delivery tube. This flexible tube was attached in between the furrow opener boot and the fluted roller cup.

V. CONCLUSIONS

The developed subsurface manure and seed applicator was tested under filed condition machine for sowing of wheat and other crops along with the placement of organic manure below the seed was tested by farm machinery and power engineering department Pantnagar Uttarakhand and found to be suitable for placing both the organic manure and seed below the soil at desired depth. The machine worked satisfactory and achieved uniform application rate of vermicompost manure in the field with reduced human power.This machine improves the nutrient uptake of plants by increasing the distribution area of roots into the soil thus increasing the soil fertility and crop productivity and safe the environment and soil with the use of inorganic fertilizer that continuously reduces the strength of soil. Surface application of vermicompost manually is less efficient and time consuming process. The newly developed machine (Fig.1) save cost of operation per unit area and the time of farmers and also improved the soil health.

ACKNOWLEDGEMENTS

I had done this study under guidance of my advisor Dr. Jayant Singh, Professor FMPE Department and all other faculty members. They guided me in every way of my research work and also all other technicians who helped me in the design of machines in the workshop.

REFERENCES

1. **Abd El-Lattief, E.A. Bread wheat (Triticum aestivum L.)** productivity and profitability as affected by method of sowing and seeding rate under Qena environment. Asian Journal of Crop Science, 3(4): 188-196.
2. **Alam,A., 1990**. Time and cost of sowing by line sowing using improved implements. Paper Presented at IJO sponsored National Seminar on jute seeder in India.
3. **Beverloo, W.A., Leniger,A. and Velde**, J.V.1961. The flow of granular solids through orifices. Chemical Engineering Science, 15(4): 260-269.
4. **Kingra,I.S and C.Singh.1986**. *Agricultural Research and Development in Himachal Pradesh*, 11-24,Govt. of Himachal Pradesh, Shimla.
5. **Damora,D and K.P.Pandey.1995**. Evaluation of performance of furrow openers of combined seed and fertilizers drills. *Soil and Tillage Research*, 34(2):127-139.
6. **Gope. P.C**: Machine design fundamentals and applications PHI learning private limited, New Delhi.

7. **Gupta,M.l.,D.K.Vatsa, and M.K.Verma.1999**. Development and Evaluation of Multicrop Planters for Hill Regions. Agricultural Mechanization in Asia, South Africa and Latin America, 30(1):17-19.
8. **Mathur,S.Mand K.P.Pandey.1992**. Influence of system parameters on performance of reversible hoe type furrow opener for animal drawn seed and fertilizer drills. In *Proc International Agricultural Engineering*. 143-150. Bangkok: Asian Institute of Technology.
9. **Olaoye,J.O.2011.** Development of a Sugarcane Juice Extractor for Small Scale Industires. IJAT. http://www.ijat-aetsea.com. ISSN 1686-9141. 7(4): 931-944.
10. **Sahay,K.M. and Singh, K.K.1994**.Unit operations of agricultural processing. Vikas Publishing Pvt. Ltd, New Delhi, 7-8.
11. **Shambhu, V.B., Nayak L.K., 2014**. "Energy Requirement in cultivation of Jute crop in West Bengal". Proceedings of the All India Seminar on Appropriate Technologies of Farm Mechanization for Marginal and Small Farmers, August 08-09, 2014, Institution of Engineers (India), Kolkata,pp. 70-76.
12. **Sharma, D.N and S. Mukesh.2008.** Farm Machinery Design Principles and Problems. New Delhi: Jain Brothers.
13. **Singh, R.C. and Sigh, C.D. 2013**. Development and performance testing of a tractor trailer-cum-farm yard manure spreader. Agricultural Engineering Today, 37(2):1-6
14. **Singh, S.2014.**Farm mechanization in hills of Uttarakhand, India-A review. Agriculture for Sustainable Development, 2(1):65-70.
15. Spotts M.F.:Design of machine element Pearson Publication new Delhi.
16. **Varhney, A.C., Kumar, U. and Naik**, R.K.2004. Sowing and planting equipment. Data book for Agricultural machine Design. CIAE/2004/01,210-245.

AUTHOR PROFILE

Abhishek Kumar, Currently pursuing Ph.D in Agricultural Engineering with a major in Farm Machinery and Power Engineering and minor in Mechanical Engineering at Govind Ballabh Pant University of Agriculture and Technology Pantnagar located in Uttarakhand State of India. I have completed B.Tech in 2010 and M.Tech in 2012 in Agricultural Engineering from G.B.P.U.A&T Pantnagar. After that I have worked as a Junior Research fellow under the project of the Department of Science and Technology. During my Ph.D work I was awarded a national fellowship of the University Grant Commission.

Dr. Jayant Singh, is currently professor in Farm Machinery and Power Engineering Department at Govind Ballabh Pant University of Agriculture and Technology Pantnagar located in Uttarakhand State of India. He is a research enthusiast and making projects into reality and has guided the students of Ph.D for almost a decade. He is currently working in the Utilization of Animal Energy scheme of Indian Council of Agricultural Research, New Delhi.