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Design and development of animal drawn plastic mulch laying machine

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Abstract
Animal powered plastic mulch laying machines were developed to mechanize traditional plastic mulching. This animal powered machine can be used for agriculture mostly in vegetable crops and some other hybrid crops. The machine components are press wheel, plastic mulch supporting unit, soil covering unit and hitching unit which are attached to the main frame of the machine. Animal drawn plastic mulch laying machine will be effortless, reduced labour cost and time, it will do both work i.e. laying the plastic mulch sheet and covering both sides of the sheet with soil by earthing unit. Various parameters such as soil clods diameter, soil moisture content, bulk density, draft, speed of operation, power requirement, time loss in turning and field efficiency were measured. The average soil moisture content of the raised beds was found 17.77% on dry basis and 15.08% on wet basis. The average values of Mean mass diameter of soil clod size was observed as 42.57 mm, which was better for raised seed bed preparation. The Draft, Speed of operation, Field efficiency was found 447.86 N, 1.35 km/h, and 70 %, respectively. The main objective of making this machine is to provide machines at the least cost to small scale farmers.

Keywords: Animal drawn, plastic mulch, machine, bullock and vegetable crops

Introduction
A protective covering (as of bark chips, sawdust, compost, paper, straw, or plastic sheeting) spread or left on the ground around plants to suppress weed growth, prevent freezing of roots, prevent excessive evaporation or erosion, enrich the soil, retaining moisture, reducing soil erosion, suppressing weed growth and providing plant nutrients as the material decomposes etc. Mulches act as barriers to movement of moisture out of the soil [1].

Mulch can be classified into organic and inorganic, Organic mulch does not always provide sufficient weed control, they can also take weed seeds and heat the soil repeatedly. This will delay the growth of the plant, especially in the spring. Weed rate cannot be controlled by organic method. Inorganic mulch, which will applying plastic will reduce the wastage of weeds on labour to clean the field. It is documented that plastic film increases the yield of many crops. The use of plastic mulch has become a standard practice for many farmers to control weeds. The plastic also moderates soil temperature in ways that increase yields and season length for farmers [2]. Black plastic mulch sheets have been used in this research. Because plastic sheets of black colour are a great way to use cauliflower, knol-khol, onion crops etc. for the winter season. Plastic films are placed before sowing or transplanting. It also includes preparation of seedbed, spread mulch film and anchoring of edges of film. There should be a raised bed has to be prepared for laying plastic film [3].

For manual mulch laying, 4 man is required, the first two persons laying the plastic on the bed and the remaining two persons required to cover the soil on the edge of the mulch film. These operations are performed manually. Takes a long time, works hard intensive, tedious and expensive. The manual method is economical for small areas but not for large areas.

The total area of vegetable crops in the Chhattisgarh state was recorded 5,25,147 ha. in the year 2019-20 with the production of 71,58,909 MT [4]. In Chhattisgarh, the Durg district is ranked first by using plastic mulching to grow vegetable. The climate of Chhattisgarh, in Raipur reason is very good for growing different variety of vegetable crops. In the state of Chhattisgarh, about 75% of the households own an average of 1.4 hectares of land [5].

In Chhattisgarh, the area of fields is in small plots, which makes it difficult to cultivate by tractors and large machinery. But for small and medium level farmers, who have only bullock and buffalo, they are available for farming.

And bullock are suitable according to small and undulating fields of Chhattisgarh. Looking at the availability of animals and size of field and situation of the small and marginal farmers in Chhattisgarh, we have designed an animal drawn mulch laying machine machine. This machine can be easily pulled by the bullock, the height of the hitching unit of this machine is adjustable to different height of the bullock, easy to transport on farm and road and very less cost laying of plastic mulch film in small and large field compared to traditional method of mulch laying. The developed animal drawn plastic mulch-laying machine has completed one pass of two operations, such as laying of mulch sheet on the raised bed and covering the soil on either side of a edges of mulch.

Materials and Methods

The study on development of animal drawn plastic mulch laying machine was caused the Department of Farm Machinery and Power Engineering, Swami Vivekananda College of Agricultural engineering & Technology and Research Station, Faculty of Agricultural Engineering, IGKV, Raipur. The machine was fabricated in the workshop of the college.

Design and Constructional Details of Animal Drawn Plastic Mulch Laying Machine

The animal drawn plastic mulch laying machine consists of following parts. The details of specification of developed machine is given in

1. Main frame
2. Mulch laying unit
3. Earthing unit (Soil covering unit)
4. Press wheel
5. Handle
6. Hitching unit

The constructional details of the animal drawn plastic mulch laying machine are discussed below

Frame

Main frame was made up of G.I. pipe. The frame is the skeleton of the machine it should be rigid so as to support all the other components of the machine. The length of the frame is 1700 mm. The height of the main frame is kept as 500 mm above the ground level which can be vary as per requirement. All parts of machine like hitch, press wheel and mulch laying unit are attached with the frame.

Mulch Laying Unit

Mulch laying unit was for laying the mulch film on the pre-prepared bed. A shaft was provided in between the two pedestal bearing so that it could be used to roll the plastic film. This unit was supported by the main frame. The height of the shaft of mulch laying unit was 300 mm above the ground. Different sizes of mulch film could be used. Black plastic mulch film of size 400 meter length, 1.2 meter width and 25 micron thickness was used. (Fig. 1&2)

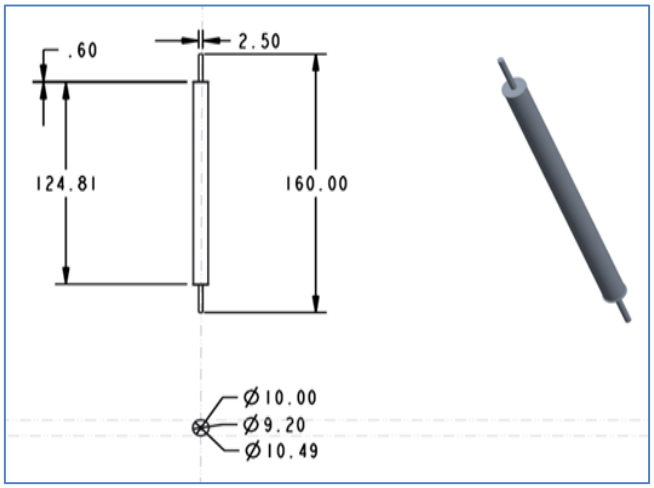

Fig 1: Auto-CAD design view of shaft

Fig 2: Black plastic sheet

Press Wheel

The operations for compacting laid mulch film on bed for protecting mulch film from the wind with the help of press wheel. Behind the mulch roller two press wheels are provided. Pneumatic or rubber wheels was used in the machine for pressing the plastic film edges to the ground. (Fig. 3)

Fig 3: Press wheel

Earthing Unit (Soil Covering Unit)

Two earthing unit was provided on both side at an angle of 60º to the direction of travel just behind the press wheel for cover the laid plastic mulch film with soil. The cross section of earthing unit was designed, in such a way that it cuts soil upto a desired depth and properly covers the plastic film. (Fig. 4)

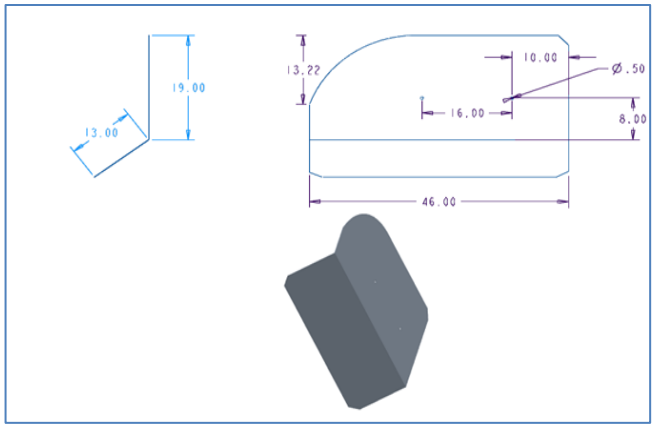

Fig 4: Auto-CAD design view of soil covering unit

Hitching Unit

A single point linkage was fabricated to hitch the mulch laying machine by pair the draught animal. The hitch was made up of MS pipe. Beam is designed in such a way that it can be easily pulled and handled by animal. The beam can be easily detached and attached with the help of nuts and bolts.

Fabrication of the Machine

Solid works design and drawing (Fig.5&6) was used for the design, development and fabrication of the animal drawn plastic mulch laying machine. The different component of the mulch laying machine mentioned in previously described sub headings was fabricated and assembled in the workshop of Swami Vivekananda College of Agricultural engineering & Technology and Research Station, Faculty of Agricultural Engineering, I.G.K.V., Raipur. Assembled view of animal drawn mulch laying machine is shown in Fig 6. The details of specification of developed machine is given in Table 2.

Table 1: Material used for fabrication of different component of the developed machine

S. No.	Particulars	Material specification	Size
1	Main frame	G.I. pipe	1700 mm length, 60 mm OD
2	Mulch laying unit	Circular clamp	OD 70 mm
		Shaft	1600 mm length, 25 mm OD
		Stoppers	105 mm length
		Black plastic mulch film	400 m length, 1.2 m width, 25 micron thick
3	Press wheel	Pneumatic or rubber wheel	3.50- 8, 4 PR (Ply rating)
4	Soil covering unit	MS sheet	460 mm length, 320 mm height and 130° angle
5	Pressing handle	MS pipe	780 mm length, 25 mm OD
6	Hitching unit	MS pipe	760 mm length, 60 mm OD
7	Beam	MS pipe	2680 mm length, 60 mm OD

Table 2: Specification of animal drawn plastic mulch laying machine

Sr. No.	Particulars	Specification
1	Overall Dimension L x W x H, mm	4780 x 1700 x 500
2	No. of press wheels	2
3	Diameter of press wheel, mm	360
4	Size of press wheel	3.50-8, 4 PR
5	No. of earthing unit	2
6	Thickness of plastic mulch, micron	25
7	Length of plastic mulch, m	400
8	Width of plastic mulch, m	1.2
9	Source of power	A pair of bullock
10	Total weight of the machine, Kg	75
11	Cost of machine, Rs.	11,500/-
12	Operational energy of machine, MJ/ha	177

The machine was tested at research plots of PFDC, IGKV for laying plastic mulch on pre-prepared bed of following sizes:

1. Width of bed - 600 mm
2. Height of bed - 150 mm
3. Length of bed - 57 m
4. No. of bed - 12
5. Date of start : April 2017
6. Likely date of completion : March 2018

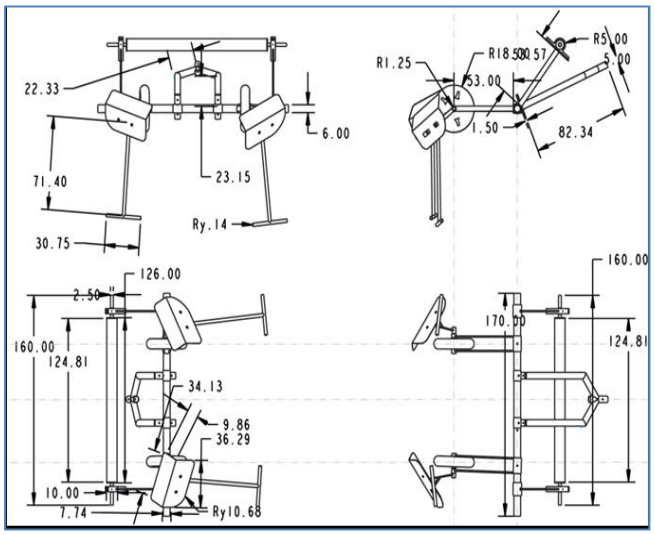

Fig 5: Auto-CAD design of animal drawn plastic mulch laying machine

Fig 6: 3-D Solid projection of developed animal drawn plastic mulch laying machine

System Flow Diagram

Methodology used for whole processing of design and development of animal drawn plastic mulch laying machine is given below; this methodology gives way about how work is to be carried out in systematic way. It is standard process of describing process, how it is done in simplest manner.

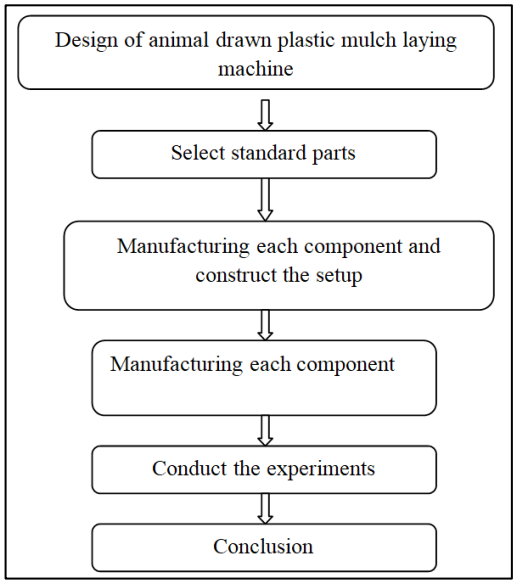

Fig 7: System flow diagram

Results and Discussions

The developed implement (Fig.6) was tested in the experimental plots for laying of plastic film on the prepared bed. The developed machine was effective for laying mulch film and cover laid plastic mulch film from both side with soil. The effective field capacity was found to 0.162 ha/h at an average speed of 1.35 km/h with a field efficiency of 69.67 per cent. The average draught required to pull the machine was found to be 45.70 kgf, which was within the capacity of local bullocks found in this region. It was observed that the actual field capacity of developed mulch laying machine 0.113 ha/h. Finally it was observed that cost of operation of traditional method is highest i.e, 9615 Rs/ha then followed by of mulch laying machine which is 1205 Rs/ha. (Depicted in Table no.3)

Table 3: Different test of the performance evaluation of animal drawn plastic mulch laying machine

Sr. No.	Particulars	Result
1.	TFC, (ha/h)	0.162
2.	AFC, (ha/h)	0.113
3.	FE%	69.67
4.	Draft, kgf	45.70
	Power, kW	0.162
5.	Speed of operation, kmph	1.35
6.	Source of power	A pair of bullock
7.	Time req. h/ha	9
8.	Cost of the machine (Prototype), Rs	11,500

Conclusions

It was concluded that the developed animal drawn plastic mulch laying machine have-

- The field capacity of the machine may be increased, if the trial may be conducted on long bed for more than 100 m length.
- Mulch laying machine is proven as cost effective technology for laying of plastic mulch in vegetable farms.
- The draft requirement of developed machine was within the pulling capacity of local drought animal.
- It saves time, labour and increases timeliness of operation. By using plastic mulch of black colour, it maintains the soil moisture and soil temperature.
- Low cost which can be affordable for the farmers.

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