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Performance evaluation of animal drawn plastic mulch laying machine

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Abstract
The present study was aimed to increasing the plasticulture cultivation by using plastic materials to modify the production environment in vegetable crop production. Existing animal drawn plastic mulch laying machine was developed at SVCAET & RS and Faculty of Agricultural Engineering, I.G.K.V., Raipur (C.G.). The prototype of animal drawn plastic mulch laying machine, consisting of a main frame, press wheel, supporting frame for mounting mulch roller, earthing (soil covering) unit and hitching unit. During the field test the draught, operational speed and power requirement were recorded as 447.86 N, 1.35 kmph and 0.162 kW, respectively. The effective field capacity and field efficiency of the machine was found 0.113 ha/h and 69.67%. The energy consumption and cost of operation was found 177 MJ/ha and 1205 Rs/ha. On the basis of the findings all over performance of the developed plastic mulch laying machine was found better as compared to traditional method and the performance of the machine was found as per desirable.

Keywords: Mulching, plastic mulch, laying of mulch, mulch laying machine, animal drawn implements, draught animals

Introduction
Mulch, being a natural resource, has become one of the most effective technologies for optimum yield and quality enhancement of crops besides reducing the cost of production. The use of plastic mulch in agriculture has been increased dramatically in the last 10 years throughout the world. This increase is due to the benefits such as increase in soil temperatures, easy of weed management, moisture conservation, reduction of certain insect pests, high crop yields, less crop contamination, less soil compaction and improved germination rates and more efficient use of soil nutrients (Gowd and Prasad, 2017). These benefits lead to higher yields (by up to 100% for certain crops) in early duration crops (by upto one month) and in some case the ability to grow certain crop, which would not be possible without the mulch film (Clarkson, 1957)**.** According to Reynolds (2009), Globally every year over 80,000 square km of agricultural lands are covered with plastic mulch films.

Plasticulture is the art of using plastic materials to modify the production environment in vegetable crop production. They are used commercially for both vegetables and small fruit crops. To be more competitive in today's markets, vegetable growers are looking for new ways to achieve higher-quality produce, superior yields, and early spring markets. The plasticulture system–which combines raised beds**,** plastic mulch**,** drip irrigation**,** and fumigation has helped an increasing number of producers reach these goals. Growers using the plasticulture system have doubled and tripled yields and harvested their crops two to three weeks earlier than is possible with traditional growing practices. Agricultural work in Use of mulching machine in India is increasing day by day.

Nowadays in India, it is necessary to do farming in smart way to save the natural resourses. Most of the farmers use different agricultural methods to cultivate their cereal. But during the period of seeding and harvesting they spend lots of money on labours and on old water feeding technique to the plants, and lastly they will not gain that much as they wished or they deserved. So for all those farmers mulching machine is the best way to recover and redeveloped farming in foreign style. Traditional; manual mulching process characterized as labour intensive, poor quality of work, disturbances due to wind during laying of mulch sheet, tearing of sheet during handling and difficulty in the covering of mulch sheet. Presently, for laying plastic mulch sheet manually and laying operation are 3 to 4 labours are required. India is carried out by using manual, animal and mechanical power sources. Power operated machine is economical but needed specific characteristics for effective working such as high land holding, uniformity in the topography, needed road facility to reach the machinery in the field as well as high hp power sources (high hp tractor) to operate the machine.

Such conditions are not possible to maintain in the Chattisgarh. There is need to develop a mulching machine which can be suitable to operate in Chattisgarh condition, operated by animal, easily possible to transport in the field, effective in operation, minimizing the labour forces involved in operation and economical to use for small farmer.

Materials and Methods

Development of the plastic mulch laying machine was done in the workshop of SVCAET, FAE, IGKV, Raipur with standard procedure.

Constructional Details of Plastic Mulch Laying Machine

Mulch laying unit

Mulch laying unit was for laying the mulch film on the pre-prepared bed. The mulch laying unit was fabricated by two MS flat (40 × 10 mm), each of which was connected to main frame at one end through circular clamp (OD 70 mm) and the other end to the bearing housing with the help of welding. A shaft was provided in between the two pedestal bearing so that it could be used to roll the plastic film. The plastic film was inserted on the shaft by removing it from pedestal bearing at one side. This unit was supported by the main frame. The height of the shaft of mulch laying unit was 300 mm above the ground. The length of mulch laying unit shaft was 1620 mm. Two stoppers of MS sheet was cut in circular form and mounted on the mulch roller at both end before the bearing to keep mulch film at desired position. 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. This mulch film was suitable to be used for different bed size. A pair of bullock was used for pulling the implement, one person holded the mulch film on the bund behind the machine before starting the operation, two handle were used to apply weight on the earthing unit while in operation that facilitated the proper functioning of the earthing unit, the mulch film rotated automatically because of the shaft and the mulch film was laid on the bed. Fig.1 shows the Auto-CAD design view of shaft.

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 size (3.50–8, 4PR) was used in the machine for pressing the plastic film edges to the ground. Press wheels were attached to the main frame by MS flat (40×10mm). Center to center distance of both wheels were 940 mm. The function of press wheels was to press the mulch film on the bed so that, plastic film could be laid easily and properly and it remained always in contact with the soil bed. Fig.1 shows the Auto-CAD design view of 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. It digged the soil up to a depth of about 5-7 cm and gathered soil of about 250-300 grams on 20 cm length of plastic film. The length, height and thickness of earthing unit was 460 mm, 320 mm and 12 gauge respectively. An angle of 130º was given at center of the MS plate for proper collection of soil. The earthing unit was made up of MS sheet. The spacing between two earthing unit was 940 mm. Fig.1 shows the Auto-CAD design view of earthing unit.

Table 1: Details of field experiment

1.	Test Crop	Cauliflower and Knolkhol
2.	Season	Rabi
3.	Start of study	April, 2017
4.	Completion of study	April, 2018
5.	Row to row spacing	50 m
6.	Plant to plant spacing	40 cm
7.	Distance between two treatment plots	1 m
8.	Method of mulch laying	1. Developed mulch laying machine 2. Traditional method of mulch laying
9.	Date of testing	8 January 2018
10.	Date of sowing	11 January 2018

The following parameters were taken during the field test:

Operating speed
Power requirement
Field Capacity
Field efficiency

Operating Speed

The speed of operation was measured by recording the time required to cover 30 m distance in the field during operation.

$$\text{Speed (km/hr)} = \frac{3.6 \text{ x distance traveled (m)}}{\text{time (s)}}$$

Power Requirement

The power requirement was determined from draft and speed using the relation

$$\text{Power (hp)} = \frac{\text{Draft} \times \text{speed}}{75}$$

Where

Draft in kgf, and Speed in m/s

Field Capacity

Theoretical field capacity was calculated by following formula

$$\text{TFC (ha/h)} = \frac{(W \times S)}{10}$$

Where

S = Speed of operation, km/h; and
W = Theoretical width covered, m;

Field efficiency

The field efficiency is the ratio of effective field capacity to the theoretical field capacity and expressed in per cent.

$$\text{Field efficiency} = \frac{\text{Effective field capacity}}{\text{Theoretical field capacity}}$$

Table 2: Field condition during the test

S. No.	Particulars	Situation
1.	Location	SVCAET Testing plot
2.	Type of soil	Sandy loam
3.	Moisture content of soil	15.08 % wb and 17.77 % db
4.	Bulk density of soil	1.41g/cm^3
6.	Area taken for field performance	45 × 25 m^2
7.	Field preparation	MB plough, cultivator and rotavator

Table 3: Findings of field performance of different method of mulch laying

Parameters	Data of field performance	
	Traditional method	Plastic mulch laying machine
Draft, N	----------	447.86
Speed, km/h	0.244	1.35
Effective field capacity, ha/h	0.013	0.113
Field efficiency, %	----------	69.67
Energy consumption, MJ/ha	603.68	177
Time required, ha/h	77	9

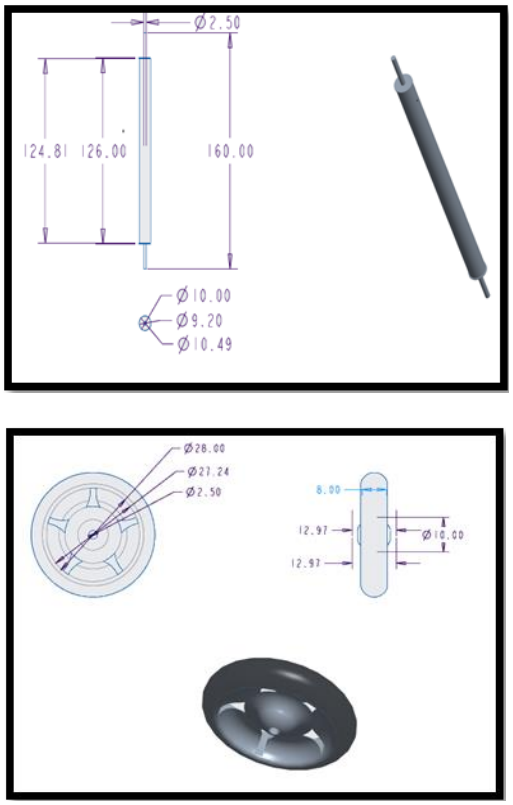

Fig 1: Auto-CAD design view of (a) Shaft, (b) Press wheel and (c) Earthing unit

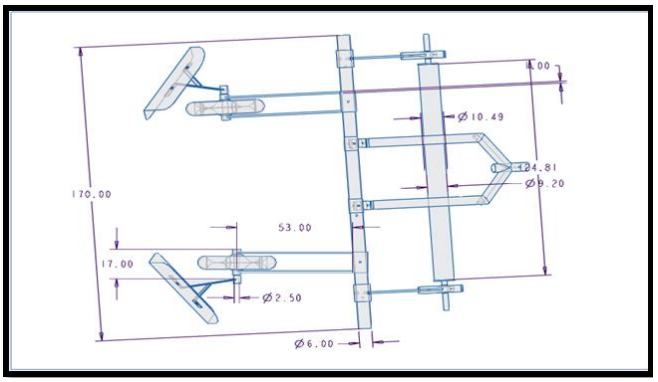

Fig 2: Top view of the plastic mulch laying machine

Fig 3: 3-D Solid projection of the plastic mulch laying machine

Fig 4: Field testing of developed machine

Results and Discussion

There are two method was taken during the plastic mulch laying i.e. traditional method of mulch laying and animal drawn plastic mulch laying machie. The field condition during the test was given in table.1 and the field performance of the both method is given in table.2. It reveals that the maximum energy consumed 603.68 MJ/ha was recorded under laying of plastic by manually method of mulching. Developed mulch laying machine was consumed less energy 177 MJ/ha. Finally it was observed that On the basis of the findings

overall performance of the 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 was found better as compared to mulch laying machine and the cost of the machine is within the buying capacity of the small and marginal farmers. Modification made in the mulch laying machine resulted by earting unit with satisfactory covering the soil on the plastic film.

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