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Research Article

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Design and Development of Manual Plastic Mulch Laying Machine

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ABSTRACT

In India, the farming operation such as transplanting, harvesting, threshing is mostly done by labour which is time consuming and costlier also. Most of the time irrigation is one of the biggest problem in India. So mulching machine is the best way to recover and redeveloped farming in different style. Manual mulching process characterized as labour intensive, poor quality of work, disturbances due to wind during laying of mulch sheet additionally causes problem of tearing of sheet during handling and most importantly difficulty in the covering of mulch sheet. So new manual mulching machine was developed which can be operate by labour easily, with possible to transport in the field, effective in operation, minimizing the labour forces involved in operation and economical to use for small farmer.

Key word: *Manual, Mulching machine, Labour intensive,*

INTRODUCTION

Mulching means a protective covering to prevent reduction of moisture content by using leaves, straw or peat placed around plants. This mulching indirectly helps in control of weed. Vegetable growers are looking for new ways to achieve higher-quality produce, superior yields, and early spring markets for more completion in market. The plasticulture system which combines raised beds, plastic mulch**,** drip irrigation, and fumigation has helped an increasing number of producers reach these goals. There are automatic machines but they are either not available in U.P. or the use is limited to large scale farming[2]. In Allahabad most of the agricultural operations are carried out by using manual labour which is costlier. Most of the marginal and small farmers in this region depend on manual labour for farm operations like tillage, sowing, and threshing operations. In U.P. average power availability is 1.09 kW/ha less than the national average 1.5 kW/ha with a contribution of human power as 48.39 percent[1].

The demand for mulching machine in India is increasing day by day. Most of the farming operation such as transplanting, harvesting, threshing is done by labour which is time consuming and costlier also and lastly they will not gain that much benefit as they wished or they deserved.

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So mulching machine is the best way to recover and redeveloped farming in different style. Traditional; manual mulching process characterized as labour intensive, poor quality of work, disturbances due to wind during laying of mulch sheet additionally causes problem of tearing of sheet during handling and most importantly difficulty in the covering of mulch sheet. Presently, for laying plastic mulch sheet manually around 4-5 labours are required. Power operated machine is effective but not economical for small farmers and it requires larger field, uniformity in the topography, needed road facility to reach the machinery in the field as well as high powered tractor is required to operate the machine. It is very difficult to find such situation in UP, so need to develop a mulching machine which can be operate by labour easily, with possible to transport in the field, effective in operation, minimizing the labour forces involved in operation and economical to use for small farmer. Keeping in view the above, the present study was undertaken to design and to test in field the manual mulch laying machine.

MATERIAL AND METHODS

The Development of manual plastic mulch laying machine was designed as a functional and experimental unit. The design of machine components was based on the principles of operations and field tests. It was compared with the traditional method, to give a correct shape in form of prototype. The mechanical design details were also given with due attention so that it gave adequate functional rigidity for the design of machine.

Theoretical consideration for design

The development of manual plastic mulch laying machine consists of several steps and would require basic information about the following:

1. The developed machine will be human operated hence the total power requirement should not exceed the power available.
2. Soil and climatic conditions during planting seasons.
3. Agronomical requirements of the vegetable crops.
4. Field condition during mulch laying.
5. Labour requirements for mulch laying.
6. Socio-economic conditions of farmers.
7. Size of land holding.
8. Level of manufacturing skill at small finished components.
9. Ease of operation and maintenance.
10. Safety in operation and operator's comfort.
11. Expected level of cost of machine and cost of operation.
12. Computer aided drawing of the machine
13. Predict the performance of machine at the recommended operational speeds.
14. The economic justification could be based upon its long usage or related to the overcoming the timeliness constraints and effect on yield in conjunction with other essential inputs
15. Fabricate the prototype, according to the design specifications.
16. Determine the performance of the prototype in laboratory as well as under actual field conditions with respect to, field capacity, field efficiency etc.
17. Modify the machine, if changes are required to achieve expected level of performance.
18. Finalize the design.

General design consideration

Functional requirements

The mulch laying machine developed should fulfill the following functional requirements:

1. Laying of the mulch film on the pre-prepared bed.
2. The operations for compacting laid mulch film on bed for protecting mulch film from the wind with the help of press wheel.
3. Provision of earthing unit to cover laid plastic mulch film from both side with soil.

Agronomical requirements

Following agronomical requirements were also considered for design of machine:

Bed width = 60 - 80cm
Bed height = 10 - 15 cm
Width of plastic mulch film= 1- 1.20 m.

RESULT AND DISCUSSION

Design of Manually operated plastic mulch laying machine

Power developed by the operator

The power of useful work done by an average human on the drive machine is given by the power of useful work done by human being is given by

HP = 0.35-0.092log *t*

An average human can work on field for 2-4 hours continuous. (Let's consider 2 hr)

HP = 0.35-0.092log 120= 0.158 hp

Pull force required to operate mulch laying machine

$$\text{HP} = \frac{\text{Pull(kgf) X Speed(m/s)}}{75}$$

$$\text{Pull force that can be developed by average human} = \frac{\text{HP X 75}}{\text{Speed(m/s)}}$$

$$= \frac{0.159 \text{ X } 75}{0.41 \text{ (m/s)}} = 28.9\text{kg}$$

Let's take speed = 1.5 kmph = 0.41 m/s

Draft requirement

$D = P \cos\theta$

Where,

D = Draft, kg

P = Pull (weight of machine), kg = 25 kg

θ = Angle between line of pull and horizontal, degrees $=40^0$

D = 25 Cos40

= 19.15 kg

Calculation of diameter of disc (Dd)

$$\text{Calculation of diameter of disc (Dd)} = \frac{\text{K x dp}}{\cos\beta}$$ ……(Sharma and Mukesh 2013)[5]

Where,

K = Coefficient (ranges 2.5-3 for deep tilling)

d_p = Depth of ploughing, cm {Let's take 10 cm}

β = Tilt angle of disc with vertical (15^0-25^0)

$$(\text{Dd}) = \frac{3 \text{ x } 10}{\cos 25}$$

= 33.1 cm

Width of cut $W = Dd/3 = 33.1/3 = 11.03$ cm

Radius of curvature of disc

$$R = \frac{Dd}{2\sin Ø}$$

Where,

Ø = Half center angle of arc of circle formed by cutting disc on equatorial plane

$Ø = \alpha - i - \varepsilon$

α = Disc angle 45^0

i = Sharpness/ tapperness of disc (15^0-25^0)

ε = Back cleaning angle 3^0-5^0

$Ø = 45^0\text{-}20^0\text{-}4^0 = 21^0$

$R = \frac{33}{2\sin 21} = 46$ mm

Thickness of disc $T_d = 0.008D_d + 1$

= 0.008x 33 + 1= 1.2 mm

Note: As per the designed condition and availability of material in market 38 cm diameter and 5 mm thick disc has been used.

Design theory of parts of manually operated plastic mulch laying machine

Design of handle

The handle of the implement is designed on the basis of the working position of the operator. Pushing and pulling capability largely depends on a complex interaction of posture, shoe/floor friction and subject to anthropometry. If μ (coefficient of friction) between operator's shoe and the soil surface is 0.3, the push force exerted may be 20kg. With μ of about 0.6 the push force capability may increase to about 30 kg. The person with large reach and high body weight can achieve high pull force if also provided with high traction surfaces and enough space to lean. In the showing operation the value of μ from 0.4 to 0.7

Handle height

Handle position in pushing/pulling tasks have been standardized by many research workers some relevant finding is given below:

Handle heights for maximum pushing capability

S.NO.	Study conducted by	Handle height (mm)for maximum push
1.	Martin & Chaffin (1972)	500-900
2.	Ayob & M.C. Daniel (1974)	910-1140
3.	Kroomer (1974)	860-1230(70to80%shoulder height)
4.	Snook(1978)	890 for female and 950for males
5.	Chaffin(1983)	680-1090

(Source: Gite, 1950)

The maintenance of neutral position of the operator's hands is the least fatiguing and probably the most comfortable. Herberts *et al.*, reported a general increase in localized muscle fatigue as the working hand level is increased from waist to shoulder and above, as reported by Gite. Therefore, Ayoub and Mcdaniel and Chaffin *et al*., have recommended the minimum height 800 to 900 mm for Indian workers. Therefore, machine handle height was kept as 850 mm

Handle length

Length of the handle of implement and the angle of operation are interdependent. Angle of operation is based on functional design and geometry of the tool and generally lies between 30º to 45º. The length of handle can be calculated as a thumb rule in case of long handle tools the total corresponds to 0.7 to 0.8 of shoulder height. Therefore, handle length recommended for push pull type manually operation is 1000mm. however the handle length of the present machine was kept as 1030mm, keeping in view the lower angle between point of pulling and vertical plane, in order to reduce strain on hands of operator.

Handle cross bar length

Pulling and pushing power are of the same order of magnitude whether the arms are held sideways or forwards in the sagittal plane. Therefore, the hand positioning should be such that they are close to their neutral position. Thus, the length of the crossbar will depend on elbow-elbow breadth and it can be taken as 400 to 600 mm. the cross bar length of the machine is therefore kept as 450 mm.

Design of handle grips:

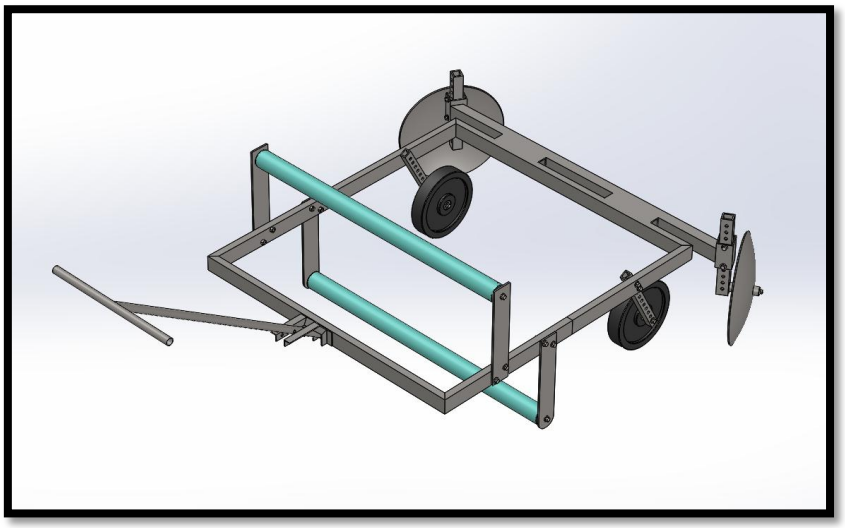
The optimum grip diameter recommended is 25-37.5 mm. the length of grip depends on hand width and its value can be taken as 130 mm however, in the planter designed for the present study one horizontal bar is provided as the grip, which facilitates the worker to adjust the position of hands while operating.

Handle material

Wood and mild steel (pipe) are common materials used for handle grips. Wood is felt for more comfortable to hand because, it has more coefficient of friction than mild steel. The relative movement between hand the grip will also be less as compared to mild steel handle. However, there is some plus point of

steel handles few of them being strength, durability, easiness in fabrication etc. therefore, the material of the handle had been selected as mild steel keeping in mind functional design requirement, human comfort and economics and other advantages stated above.

The detail parts of the machine are given below with demarcation.



1. Handle 2. Hitching Unit, 3. Mulch Laying Unit, 4. Main Frame, 5. Press Wheel, 6. Earthing Unit

3-D Solid projection of developed manual operated plastic mulch laying machine

View of developed manual operated plastic mulch laying machine

Testing of manual operated plastic mulch laying machine

A prototype of manual operated plastic mulch laying machine was developed and fabricated at the Department of FMPE VIAET SHUATS Allahabad. For testing of the machine standard methodology was adopted as per BIS test code IS: 15830:2009 for mulch laying machine.

CONCLUSION

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. Keeping in view the

above, the present study was undertaken with the following objectives to enhance the utilization of manual mulch machine for laying plastic mulch.

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