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Development of Mulching Machine as an Attachment to a Tractor Operated Rotavator

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Abstract: Agriculture is primary source of livelihood for about 58% of India's population and employs about 41.49% of total work force with a GDP contribution of 17.76% in 2019-20. Formerly agriculture was more dependent on the nature and all the operations were carried out manually, however new technologies have been developed to increase the production and productivity of crops, plastic mulching is one among them. By adopting mechanization in the required areas of agriculture, timely operations with reduced drudgery and cost of operation can be achieved. A tractor operated plastic mulching machine as an attachment to a rotavator was developed to mechanize the conventional plastic mulching by combining the various operations such as field preparation by rotavator, bund formation, drip lateral laying and mulch laying. The machine was developed to overcome the labour problems, save operational energy and to perform timely operations.

Keywords: Plastic mulching machine, rotavator, bund former, combination tillage implement, mulching machine attached to rotavator.

1. INTRODUCTION:

Agriculture is primary source of livelihood for about 58% of India's population and employs about 41.49% of total work force with a GDP contribution of 17.76% in 2019-20. Formerly agriculture was more dependent on the nature and all the operations were carried out manually, however new technologies have been developed to increase the production and productivity of crops, plastic mulching is one among them. Mulching is the process or practice of covering the soil or ground to conserve soil moisture, improving fertility and health of the soil, reducing weed growth and enhancing the visual appeal of the area. Mulches affect the plant micro climate, modifying the energy balance of the environment and decreasing the soil water loss (Tarara, 2000). The use of plastic mulch in agriculture has been increased dramatically in the last 10 years throughout the world. Globally every year over 80,000 square km of agricultural lands are covered with plastic mulch films. Plastic mulch films are laid before crop planting or transplanting. This includes field preparation, preparation of seed bed, laying of the drip laterals, spreading of mulch film on prepared bed

and covering of edges of mulch film by soil. When these operations done individually, they require more time and energy.

Traditionally mulching is done by manually or with the help of animals. Traditional methods of using animal or human power in bed preparation and mulch laying are time consuming, labour intensive, tedious and costly which results in improper laying of plastic mulch paper, poor quality of work, tearing of paper during handling and laying and difficulties in covering of edges of mulch sheet.

Approximately 20% of energy in agriculture is used for field operations, with a majority of this energy applied toward tillage operations (Stout, 1984). In modern agriculture, tractor with various implements has become one of the major sources of power in field which is generally used for majority of the agricultural operations. Generally good pulverization of soil is achieved in a single pass of a rotavator. One operation of rotavator does a job equivalent to one ploughing and two harrowing. If both the operations i.e., seed bed preparation and mulching are performed simultaneously then it will save time and energy.

By adopting mechanization in the required areas of agriculture, timely operations with reduced drudgery and cost of operation can be achieved. A tractor operated plastic mulching machine as an attachment to a rotavator was developed to mechanize the conventional plastic mulching by combining the various operations such as field preparation by rotavator, bund formation, drip lateral laying and mulch laying. The machine was developed to overcome the labour problems, save operational energy and to perform timely operations.

2. METHODOLOGY

The developed machine consists of bund former, mulch laying unit, drip lateral laying unit, press wheels and soil covering discs. The machine was designed in design software Creo (Version 4.0). A plastic mulch roll was selected based on the width of plastic mulching on raised soil beds.

2.1 Working principle

The developed machine prepares a field by tilling, pulverizing and levelling the field with the help of rotavator and forms a soil bund using the bund former attached at rear end of the rotavator. Simultaneously, the machine lays the drip lateral and the plastic mulch sheet over the prepared soil bund. Both the edges of the plastic sheet as a mulch are covered by the soil using soil covering discs. Thus, all the operations are completed in a single pass.

2.2 Development of machine

The machine consists of following components.

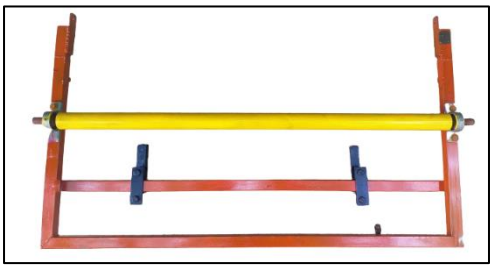
1. Main frame
2. Plastic mulch laying unit
3. Drip irrigation pipe laying unit
4. Bund making unit
5. Press wheel
6. Soil covering unit

The constructional details of the components of the tractor operated mulch laying machine are discussed below.

1. Main frame

The rectangular main frame was made up of mild steel square pipe of 40x40 mm with thickness of 2 mm having overall dimension of 1300 × 830 mm. The main frame of mulching machine was attached to rotavator by nut and bolts. All parts of machine such as press wheel, mulch laying unit and soil covering unit were mounted on the main frame by their holders using nuts and bolts. Main frame of the developed machine is shown in fig. 1.

Fig. 1: Plastic mulch laying unit mounted on main frame of mulching machine



2. Plastic mulch laying unit

The function of plastic mulch laying unit is to lay the plastic mulch sheet on the prepared bed. The plastic mulch roll carrier of mulch laying unit was attached on main frame (shown in fig. 1) by two pillow block bearing (P205). Two flanges were placed at each end of shaft to avoid sliding of mulch roll from its position.

3. Drip laying unit

For holding drip irrigation pipes a roller of diameter 100 mm and 600 mm wide was used. Four pair of 400 mm long MS flat (20x3 mm) were welded at the edges of the roller to hold drip laterals. The roller was mounted on a circular pipe. The pipe has 650 mm length and 25 mm diameter which was mounted on the rotavator. The detailed view of the drip irrigation pipe laying unit is shown in fig. 2.

Fig. 2: Drip laying unit

4. Bund making unit

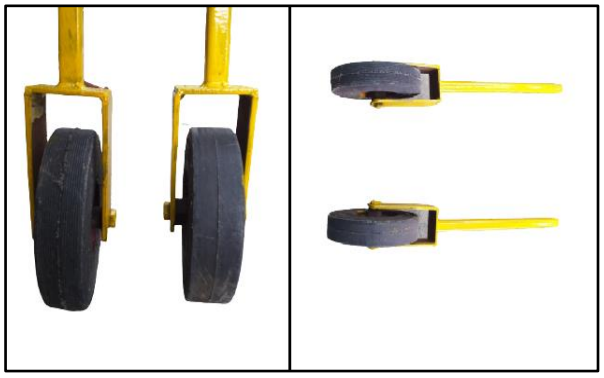
Formation of bund on pulverized soil was done simultaneously with other operations. Bund former unit was attached at the rear end of rotavator (shown in fig. 3). A bund former was designed in such a way that a bund of 750 mm to 900 mm width can form. It collected soil mass from front and converged it in compacted form at rear end as bund. It is made up of 4 mm MS sheet having length of 350 mm and height of 280 mm. The spacing between front opening part of bund former was 1230 mm and at rear part was 750 mm.

Fig. 3: Bund making unit attached to rotavator

5. Press wheels

A pair of solid rubber press wheels of diameter 200 mm and width of 50 mm were used in the machine for pressing the edges of the plastic film on the ground, which were attached behind the mulch laying unit on main frame. They help to protect plastic mulch sheet from the wind. Press wheels were attached to the main frame by clamp on which the holder MS flat (60X30 mm) was welded. In the holder MS square pipe (40x40 mm) of length 350 mm was held by nut bolt assembly. Press wheels are shown in fig. 4.

Fig. 4: Press wheels



6. Soil covering discs

Two concave circular discs were used as soil covering unit on both side of frame at rear end. They are placed at an angle of 45° to the direction of travel just behind the press wheel to cover the laid plastic mulch film with soil. Its position in such a way that it cuts soil up to a desired depth and properly covers the plastic film. The diameter and thickness of disc were 450 mm and 3 mm respectively. On the main discs, supporting discs of 150 mm diameter and 6 mm thickness was bolted to give rigidity against deflection and bending of disc. Discs were assembled with its holder of square rod (40x40 mm) and two bearing hubs for free rotation. Soil covering discs are shown in fig. 5.

Fig. 5: soil covering discs

2.3 Experimental work

The machine was designed in design software Creo (Version 4.0). The fabrication and testing work was carried out at the Department of Farm Machinery and Power Engineering, College of Agricultural Engineering and Technology, Junagadh Agricultural University, Junagadh.

2.4 Conceptual design

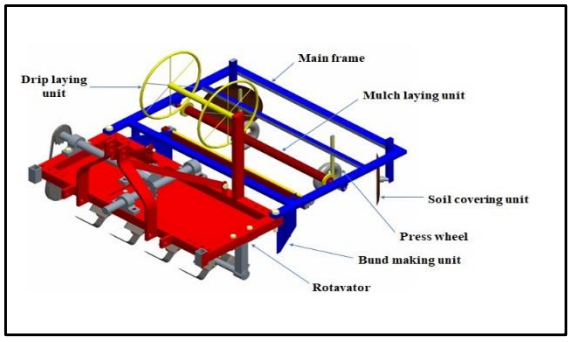


Fig. 6: Isometric view of developed machine

Fig. 7: Detailed view of developed mulching machine

3. Results/ conclusion

The mulching machine as an attachment to a tractor operated rotavator was developed to mechanize the traditional methods of mulch laying and the developed machine was evaluated in field. During the performance evaluation the machine worked satisfactorily and formed bund of required width. Also, the machine laid the plastic mulch sheet without tearing.

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