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## Research Paper

# *Manual Multipurpose Machine for Drip cum Plastic Mulch Laying and Recollection for Reuse in Crop Production*

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## ABSTRACT

Plastic mulching is a soil moisture conservation method that involves placing poly film over raised or a flat bed to provide a more favorable environment for growth and production. Plastic mulch normally is used in conjunction with drip irrigation to maintain optimum soil moisture and for improved stand establishment. Plastic film mulching with drip irrigation is a proven technology for vegetable production and its popularity is ever increasing among vegetable growers. Mulches leave behind large amount of plastic in the soil which in the current practice is buried or burned in the field which are both hazardous to environment. So, a mechanism is to be developed for retrieval of mulches for reuse or recycle. Basic mulch laying technique should include that mulch is stretched and placed firmly against compacted soil and edges of mulch are properly buried under soil, so, that wind can't loosen them. Tractor operated mulch laying machine is available but its use is limited to large areas and where crop spacing allows it as area lost in between two rows is very large. To suit the requirement of small farmers partial mechanization of laying of mulch film is envisaged by developing a Manual Multipurpose trolley for plastic mulch laying and recollection. This machine besides being simple in design and operation also caters to a very important operation, which is otherwise overlooked, that is of retrieving the used plastic mulch by rolling it back for better storage which significantly enhances its life beside being environment friendly.

**Keywords:** Plastic mulch; Drip irrigation; Manual multipurpose trolley; Recycling; Reuse; Mechanization.

## INTRODUCTION

Laying of mulch and drip laterals can be done manually or through mulch cum drip layer. In manual plastic mulch laying, beds of suitable size are prepared and drip lines are laid on the beds. After that mulch film is laid on beds. The mulch film must be covered with the soil at the same time because wind may disturb the alignment. Holes of suitable size are made on the film. But this is very time consuming and laborious process. It increases the cost of cultivation because it includes number of operations to be done separately.

Basic mulch laying technique should include that mulch is stretched and placed firmly against compacted soil and edges of mulch are properly buried under soil, so, that wind can't loosen them (Korpela et al., 2014). The specific issues with this are: more labor requirement in laying / removal, laying in windy condition, maintenance of crease free laid mulch on the bed, proper alignment and sizes of hole in the laid mulch, alignment of drip lateral



and longevity of mulch due to environmental degradation. A viable mulch laying technique using a mulch layer which can accommodate mulches of varying size and thickness suitable for vegetable cultivation is of prime importance and needs evaluation.

Tractor operated mulch cum drip laying machines is now commercially available. A mulch laying machine combines all the above operations at a time in single pass. The machine can perform the bed forming, drip line laying, mulch film laying, and punching holes in the film and covers the side of the film by soil in a single pass. Thus, it has a potential for reducing the labor requirement and increasing the time saving of the farmer. But there are many operational and other difficulties that has been encountered in such machines which limits its widespread. The area lost between two adjacent mulch bed is too high (30 to 35 per cent of total area). Laying of mulch in small and irregular farm becomes difficult as much space and time is required for turning and cutting the mulch roll at every corner. High initial investment for such machines, care, repair and maintenance requirements for this machine also have an impact for lesser adaptation by farmers.

To suit the requirement of small farmers partial mechanization of some operations like laying of drip laterals and laying of mulch film is envisaged by developing a manual multipurpose trolley for drip cum plastic mulch laying and recollection. This machine besides being simple in design and operation also caters to a very important operation, which is otherwise overlooked, that is of retrieving the used plastic mulch and drip lateral by rolling it back for better storage which significantly enhances its life besides being environment friendly.

## Materials and Method

Laying of plastic are be done manually or through mulch laying machine. In manual plastic mulch laying, beds of suitable size are prepared and drip lines are laid on the beds. After that mulch film is laid over it. The edges of mulch film must be covered with the soil immediately after laying so as to cover the bed because wind may disturb the alignment. Holes of suitable size are made on the film as per the spacing of crop. But this is very time consuming and laborious process. It increases the cost of cultivation because it includes large number of operations to be done separately.

Tractor operated mulch cum drip laying machines is now commercially available. A mulch laying machine combines all the above operations simultaneously in single pass. The machine can perform the bed formation, drip line laying, mulch film laying, punching the holes in the film as per desired spacing and can cover the side of the film by soil in a single pass. Thus, it has a potential for reducing the labor requirement and increasing the time saving of the farmer.

## Development of manual mulch laying and retrieving machine

Tractor operated mulch laying machine performs all the operation involved in laying in a single pass, so it is very convenient for large farms. But its suitability for small and irregular field as well as close spaced vegetable is under question as area lost between two adjacent mulched beds are very high for a close spaced crop like onion. Moreover in small field there are many other practical operational difficulties. In manual mulch laying, the cost and time

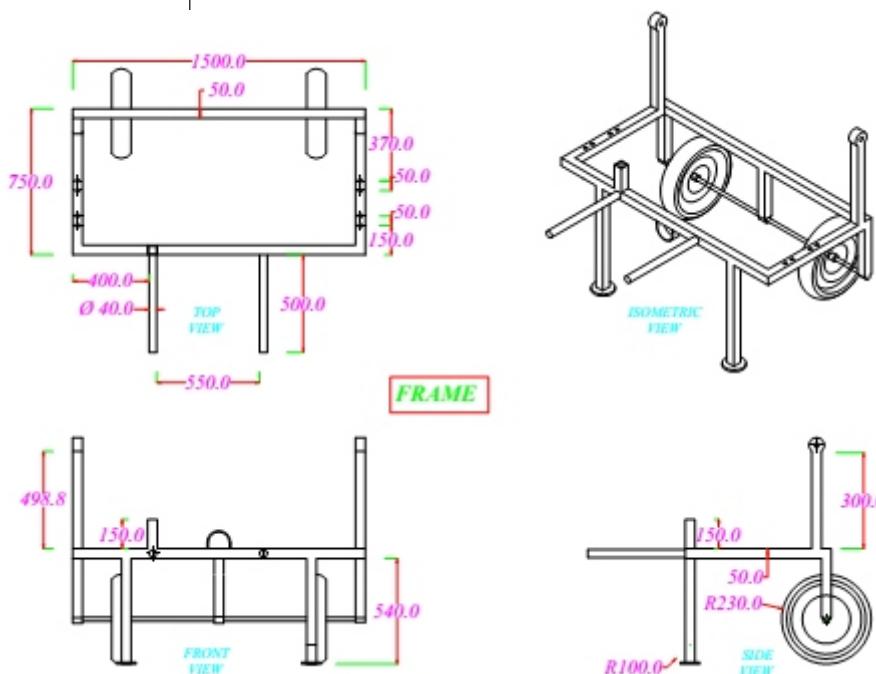
requirement is very high in laying the mulch. Also in windy conditions it becomes even more difficult. A manual mulch laying and retrieving machine was envisaged for partial mechanization of some operations involved in mulch laying like facilitating the mulch to roll and unroll while laying.

To suit the requirement of small farmers partial mechanization of some operations like laying of drip laterals and laying of mulch film is envisaged by developing a manual multipurpose trolley for drip cum plastic mulch laying and recollection. This machine besides being simple in design and operation also caters to a very important operation, which is otherwise overlooked, that is of retrieving the used plastic mulch and drip lateral by rolling it back for better storage which significantly enhances its life beside being environment friendly.

### Constructional details of the machine

The main frame is made of mild steel. The frame is deliberately made rugged to provide stability and to carry the weights of its attachments like drip rolling mechanism, Mulch rolling and to work as trolley to carry agricultural produce. The overall dimension of machine is 1500 x 750 x 650 mm and square section pipes of 5 mm thickness is used for the main frame. Total weight of the machine around 55 kg (without attachments). The main frame is supported by two rubberized pneumatic wheels on shaft and ball bearings for free movement. Two stands with round plates are provided for putting the trolley at rest position. Provision is made for adjustment of the transport wheel as per the raised bed width so as the machine runs on the furrow of the two adjacent beds. Rolling and unrolling provisions are made at suitable location of the frame for plastic mulch and drip laterals. The detailed diagram of the machine is shown in Figure 1.

All measurements are in mm



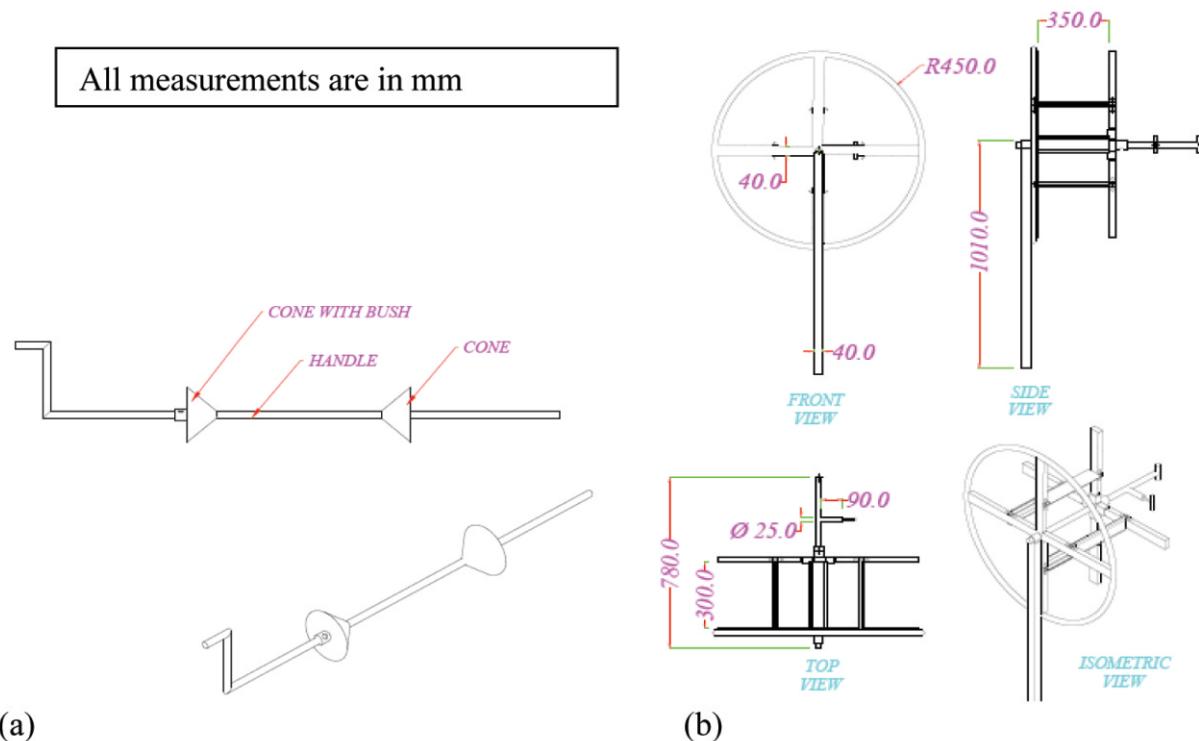
**Fig. 1. Diagrammatic details of the main frame of manual mulch cum drip laying machine**

### Attachments:

(a) *Mulch rolling and unrolling mechanism*: Two protruding square pipes near two corners are fixed with provision for putting 25 mm solid square pipe of 1750 mm (Fig. 2). Plastic roll are secured from both ends by adjustable solid cones with collars made of mild steel which facilitates plastic film to roll along with the rod through a suitable handle at one end.

(b) *Drip laying and recollection mechanism*: Projection is made with a square pipe (height 15 cm) with nut and bolt system at the rear of the machine to slide a drip rolling assembly into it for laying and collection of drip laterals. The assembly consists of a circular frame with cross spokes to secure one side and a folding and unfolding arrangement on the other side for putting the drip roll. The rotational movement of the assembly during rolling and unrolling of drip lateral is actuated by a bearing arrangement.

(c) *Support frame for use as trolley*: An adjustable extra support frame with provision for its widthwise adjustment is provided for placing of plastic carats or gunny bags for transporting agricultural produce and fertilizers.



**Fig. 2. Attachments of the machine (a) Mulch laying and retrieving mechanism (b) Drip lateral laying and collection**

## RESULTS AND DISCUSSION

### Present method of plastic mulch and drip lateral laying

Laying of mulch and drip laterals can be done manually or through mulch cum drip layer. In manual plastic mulch laying, beds of suitable size are prepared and drip lines are laid on the beds. After that mulch film is laid on bed. The mulch film must be covered with the soil at the same time because wind may disturb the alignment. Holes of suitable size are made on the film. But this is very time consuming and laborious process. It increases the cost of cultivation because it includes number of operations to be done separately. Tractor operated mulch cum drip laying machines are now commercially available.

A mulch laying machine combines all the above operations at a time in single pass. The machine can perform the bed forming, drip line laying, mulch film laying, punching the suitable holes in the film and covers the side of the film by soil in the single pass.

### Working of machine

Manual multipurpose trolley for drip cum plastic mulch laying and recollection is envisaged to perform firstly, it facilitates laying of drip line by unrolling the lateral from the assembly at one end of the prepared bed. The laying of mulch film can be performed by two unskilled labour one for pushing or pulling the trolley along with unrolling the film and the other to anchor the film with soil for crease free laying. Secondly, the layered film can be recollected with lesser effort and minimum tear by repeating previous process by running the trolley along the wet furrow of the bed and one person for rolling up of the retrieved mulch. The machine can also be used as push trolley by removing the attachments and can be used for transporting bags, crates etc.

### Comparison of different mulch laying recollection process

Comparative time and labour requirements for 0.1 ha area were also recorded on machine and manual mulching which is given in Table 1. In manual method of poly-mulch laying, two persons are required to make raised bed of 20 cm height, two persons are required to lay the plastic film mulch from the rolls and two persons are required to keep covering the edges of the plastic with soil. In manually operated multipurpose trolley the total labour requirement is reduced by half. With tractor drawn machine the labour requirement reduces to two (Operator and helper). The time required to complete 0.1 ha was 8 h- 50 min for manual laying, 4 h-52 min for multi utility trolley and 0 h- 24 min for tractor operated machine laying comprising of simultaneous raised bed making, laying film and anchoring of the film. Labour requirement with plastic mulch laying machine was 352 man-h/ha, 135.6 man-h/ha and 8 man-h/ha for manual laying, multi utility trolley and tractor operated mulch laying respectively. The advantage of multi utility trolley over other two methods is its simple operation and its utility in collection of drip laterals and mulch films after the end of the crop season. This is an important and environment friendly approach to collect the laid plastic mulch and drip lateral from the beds.

**Table 1.** Comparison of manual method of plastic mulching and mechanization of laying process in 0.1 ha area

Unit Operations	Manual Mulching	Manual Multi-utility trolley	Mulching with plastic mulch laying machine
Person required to make bed of 75 cm top width	2	2	-
Persons required to press and hold plastic rolls	2	1	-
No. of persons required to press the sheet and put the soil on the edges of plastic sheet	1	1	-
Total number of the persons required	5	4	2 (one operator and one helper)
Time required to cover 0.1 ha area, h-min	8h-50 min	4h-52 min	0 h-24 min
Field capacity, ha/h	0.011	0.02	0.257
Labour requirement, man-h/ha	352	135.6	8

### Recollection of plastic mulch and drip laterals with manual mulch laying machine

Disposal of plastic mulch is a practical problem and it has to be addressed. Generally practiced options for disposal due to its difficulty in collection are either burying or destroying the mulch within or outside the field. This process can cause serious environmental threat if done in large scale. This is a huge economic loss as costly mulches which has a potential for reuse, but its utility is not exercised. The most scientific option is to collect and recycle plastic mulch. Efforts in this direction are being done in the western world. Here again the problem is high cost of collection and recycling. For places where recycling is not feasible, this study has tested a technique for recollection and storage of used plastic mulch for latter use for crops with similar crop geometry.

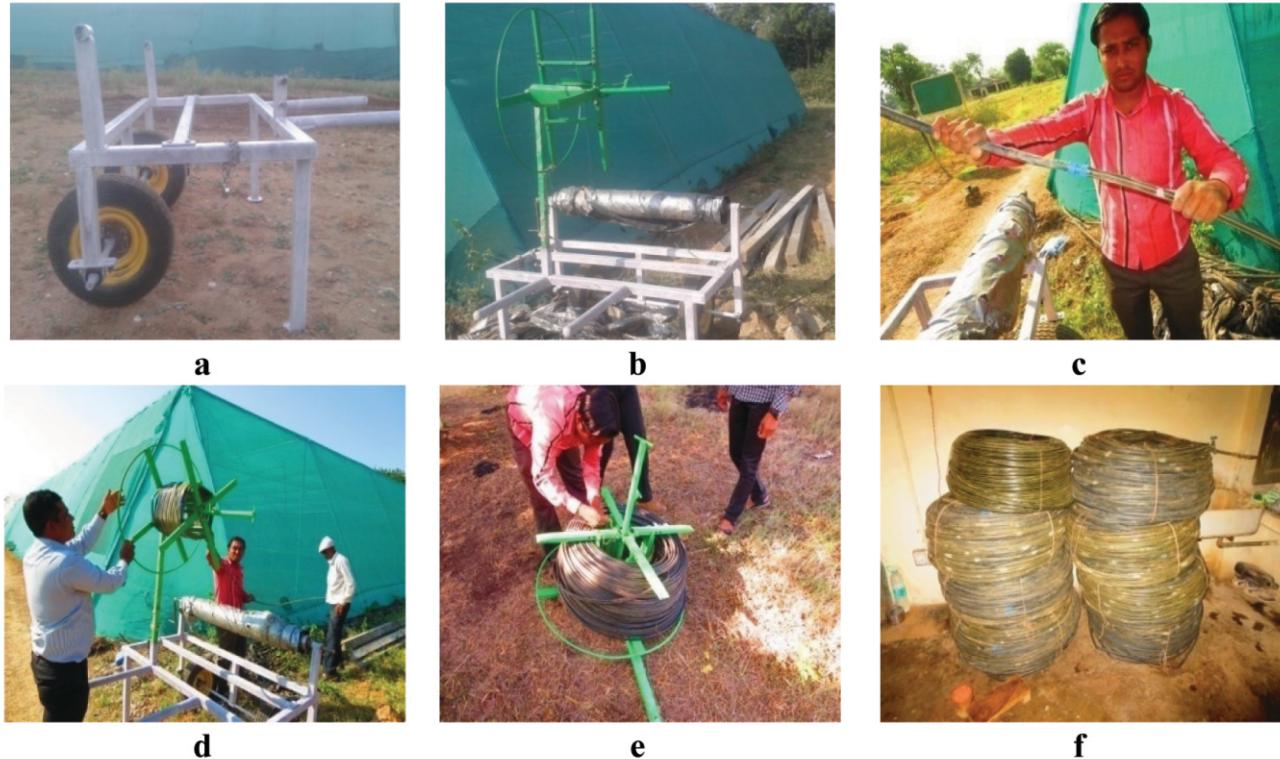
The procedure for recollection of plastic mulch from the bed for onion crop involves, allowing the plant stalk of onion to dry till it can be pulled or brushed aside easily. In some cases sickle may be required to chop off the vegetation near the onion neck. Water is applied and stagnated along the furrow between two adjacent beds and this is done one day prior to mulch removal. The mulch film which is anchored by overlaying soil is loosened and the plastic mulch on the bed is ready for removal. The manually operated trolley for mulch removal was placed with its ground wheel on the furrows of bed at one end. The attachment of mulch rolling and unrolling comprising of rod with handle embedded with cone bush secured from both end were fixed at the provided space. Two persons are required for this process, one for pushing the trolley and other person for rolling the mulch using the provided handle. The collected mulch is rolled back on a hollow cylindrical pipe made of cart board of plastic. The ends of the pipe are tightened by inserting the conical bush arrangement into the hole of the pipe so that as the pipe is rotated the hollow pipe also rotates as a single unit. Figure 3 depicts the sequential procedure involved for plastic mulch removal and recollection from the field at the end of the season.



**Fig. 3. Sequential procedure for mulch removal and collection**

Similarly, there are issues with drip laterals once the crop is over. Normal procedure is to spread the drip lateral beside the operational field for use in the next season. This process is followed because once drip lateral is unrolled and cut according to the size of the bed from the original pack, it is not practicable to roll it back as the laterals are cut in small length and the pipes tend to bend while rolling. If the lateral pipes are stored in bend position, it may develop cracks which ultimately results into damage of the laterals. Generally, the pipes which are stored and spread along the field after crop are exposed to harsh climatic condition which reduces its longevity. Moreover, it is also subject to rodent attack. This study has also tested and come up with a solution for rolling back of used drip lateral for subsequent safe storage.

The procedure involves putting a separate drip rolling assembly at a slot made for this function in the multi-purpose trolley. The assembly consists of spoked wheels as shown in Fig. 4 and Plate 1.3 which can be rotated through bearing arrangement and is supported on the trolley with square pipe fixed on a small square projection at the rear of the trolley. The cut pipe is ushered toward the drip rolling assembly by physically rolling the wheel of the assembly. Provision for taking out the rolls after completion is done by spring folding so that the bundle comes out easily once the rolling is completed. The small length of lateral pipes are joined through drip connectors. Figure shows thorough photograph in field for the collection and bundling of drip laterals from the field.



**Fig. 4. Sequential process for drip lateral rolling and bundling**

**Table 2.** Field test for field collection of mulch (total area 1000 m<sup>2</sup>)

Sl. No.	Unit Operations	Retrieval of Plastic Mulch through Multi Utility Trolley			
		Test I	Test II	Test III	Average
1.	Person required to clear mulch bed of dried onion stalk and grasses before collection	2	2	2	2
2.	Persons required to push trolley	1	1	1	1
3.	Person required to operated the handle	1	1	1	1
4.	Total number of the persons required	4	4	4	4
5.	Time required to cover 0.1 ha area, h-min	1 h-22 min	1 h-19 min	1 h-17 min	1 h-19 min
6.	Speed of Operation, km/h	1.67	1.69	1.70	1.687
7.	Theoretical Field Capacity, ha/h	0.167	0.169	0.170	0.169
8.	Effective Field Capacity, ha/h	0.102	0.104	0.105	0.104
9.	Field Efficiency, %	61.10	61.54	61.76	61.47
10.	Labour requirement, man-h/ha	54.66	52.66	51.33	52.88

Field performance test of mulch retrieval was conducted during second week of October 2015 and first week of April 2016 for understanding the effectiveness of multipurpose trolley for mulch recollection. The machine is operated by two persons, the time required to cover 0.1 ha was 1 h 19 min with a speed of operation of 1.69 km/h.

The effective field capacity was 0.10 ha/h and the field efficiency was 61.47 per cent and the labor requirement was 52.88 man-h/ha. Manually operated machine was useful in recollection of mulch and drip lateral line. It can also be used as a trolley for transport of agricultural inputs and produce.

## Conclusions

A manual operated machine was designed, fabricated and tested for mulch laying process. Manual operated machine is capable of collecting laterals, transporting farm produce/seed/fertilizer in addition to mulch laying and recollection of mulch.

Comparative study of tractor operated machine, manual machine and manual laying of mulch was made. Time required in mulching was 0h -24 min, 4 h- 52 min and 8 h-50 min for tractor operated, manual machine and manual method of laying, respectively. The additional saving achieved by virtue of collection of used mulch by manual mulch laying machine was Rs10, 888.

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