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Assessing the influence of speed of operation on soil cover thickness and width, field capacity and field efficiency

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Abstract
A mini tractor operated mulch laying machine with fertilizer arrangement machine was developed for laying of plastic mulch paper for different crops. All the machine components i.e. three-point linkage, bed former, drip lateral laying unit, fertilizer application unit, mulch paper roll carrier unit, press wheel and soil covering unit mounted on the main frame. The machine performance evaluated in the actual field conditions. The results of soil parameters concluded that, the moisture content of soil 20.4 percent, bulk density of soil 1.27 g/cm^3 and soil pulverization index 1.7 mm. The speed of operation shows their effect on the thickness of soil cover, width of soil cover, field capacity and field efficiency. The performance results concluded that, decreasing the speed of operation allows the equipment to disturb and move more soil, which results in an increases layer of soil thickness and width of the soil cover. The field capacity and field efficiency increase with higher operational speeds and improves overall productive time and reduce the non-effective time per hectare.

Keywords: Mulch paper, thickness of soil cover, speed of operation, field capacity

Introduction
Indian agriculture plays a vital role in India's economy; 70 percent of the population is engaged in agriculture and allied activities. According to Department of Agriculture and Farmer's Welfare, the horticulture production in India in 2022-23 was estimated to be about 355.48 million metric tonnes. India produced 110.21 million metric tonnes of fruits and 212.55 million metric tonnes of vegetables in 2022-23 (Anonymous 2023) [1].

The Konkan region is located in Sahyadri mountain range and expands 720 kilometres which runs along to the Arabian Sea, is famous for different agricultural practices, which include crops like horticultural crops, cashew, rice, mango and coconut. The vegetables crops such as cabbage, watermelon, capsicum, green chillies etc., grows in this region on plastic mulching. In this region faces challenges lateritic soil, undulating landscapes, excessive rainfall, low yield, insect and pest attack. (Nikam *et al.*, 2019) farmers use mulching method for improving the condition of agricultural soil by covering soil surface (Korla *et al.*, 2020) [4]. Mulch paper reduces the risk of insect pest attack to crop. Mulch layer applied to the surface of soil for the purpose of reducing evaporation, suppressing weed growth, reducing soil erosion, increasing yield, increase productivity, retaining moisture. (Reddy *et al.*, 2020) [5]. Now a days low-density polyethylene and liner low-density polyethylene mulch paper are most commonly used for mulching.

In conventional methods various problems show like time-consuming, low-quality work, poor accuracy, labour intensive and possibility of tearing sheets while handling By, considering these aspects and necessity, we developed mini tractor operated mulch laying machine with fertilizer unit. Developed machine performance show effect on the thickness of soil cover width of soil cover, field capacity and field efficiency.

Material and Methods

Soil parameters

Land preparation

Before the trials, the selected field was prepared by pulverising the soil with a 45 HP tractor to a depth of 10 to 15 cm with mould board plough and then a double cross pass using a rotavator. Mulching was laid on the fine tilth soil.

Moisture content of soil

Moisture content of soil on a wet basis was calculated by using the oven-dry method. Five soil samples from same field in different locations were taken. The weight of the collected soil sample was recorded and soil samples were kept in the oven for 2 hours at 130˚C. The moisture content of soil was calculated by using the formula (IS: 2720 (Part II)- 1973).

$$MC = \frac{W_3 - W_1}{W_2 - W_1} \times 100$$

Where,
MC = Moisture content of soil, percent (wb)
W_1 = Weight of empty moisture box, g
W_2 = Weight of dry soil and moisture box, g
W_3 = Weight of wet soil and moisture box, g

Bulk density of soil

The bulk density of soil was measured by the core cutter method. Bulk density of soil was defined as dry mass of soil per unit volume of core cutter. The soil samples were collected from same field in five different locations. The collected soil samples were initially weighed before being placed in the oven for 2 hours at 130 °C. After 2 hours, samples were taken and weighed. The bulk density of the soil sample was calculated by using the following formula: (IS: 2720 (Part XXVIII)- 1974)

$$\text{Bulk density of soil (g/cc)} = \frac{Wd}{V}$$

Where,
W_d = Weight of dry soil, g
V = Volume of metallic core cutter, cm^3

Soil pulverization

The index for soil pulverization was the measurement of the mean mass diameter of soil aggregates. One kilograms of soil sample were passed through the different series of sieves with apertures measuring >12.5, 8, 5.6, 4, 2.8, 2 and 2> mm. The set of sieves was agitated well and the weight the sample retained on each sieve was measured. The following expression was used to calculate the mean soil clod diameter (dsc) (RNAM Test Codes and Procedures for Farm Machinery, 1983).

$$\text{Dsc} = \frac{5A+15B+25C+35D+45E+NF}{W}$$

Where,
Dsc = Diameter of mean soil clod, mm;
W = A + B + C + D + E + F, kg;
N = Mean of measured diameter of soil clod retained on the largest aperture sieve, mm

Operating parameters

Speed of operation: The speed of operation was calculated by recording the time required to cover a 20 m distance in the field during working conditions. To calculate the speed of operation, two poles 20 m apart were placed approximately in the middle of the test run. On the opposite side, two poles were placed in a similar position and 20 m apart from each other. So that all four poles were on the corners of the rectangle. The speed was calculated from the time required for the machine to travel the distance of 20 m between the assumed line connecting two poles. It was recorded with the help of a stopwatch. Three measurements were recorded and the mean value was calculated. Finally, the speed of operation was calculated by using the following formula: (RNAM Test Codes and Procedures for Farm Machinery, 1983)

$$\text{Speed (km/h)} = 3.6 \times \frac{\text{Distance travelled (m)}}{Time\ (Sec)}$$

Thickness of soil cover

The thickness of soil covered on each side of laid mulch paper was measured by using measuring tape and a scale. It was an important parameter because the covering of soil on the mulching paper kept the sheet settled, tightly fixed and protected from the wind and rainfall.

Width of soil cover

The width of soil covered on each side of laid mulch paper was measured by using measuring tape and a scale.

Field performance parameters

Theoretical field capacity (ha/h)

Theoretical field capacity was the area covered by an implement at its rated width and at its rated speed. Theoretical field capacity was determined by the formula, (Sahay, 2008) [7].

$$\text{Theoretical field capacity} = \frac{Width\ (m) \times Speed\ (\text{sec})}{10}$$

Effective field capacity (ha/h)

The effective field capacity was the ratio of the total area covered in hectares to the total time required for field operation in hours. Effective field capacity was determined by the formula, (Sahay, 2008) [7].

$$\text{Effective field capacity} = \frac{A}{Tp+Ti}$$

Where,
A = Area of the test plot, ha
T_p = Productive Time, sec
T_i = Non- Productive Time, sec

Field efficiency (%)

The field efficiency was the ratio of effective field capacity to the theoretical field capacity and expressed in percentage (%). Field efficiency was calculated by the following formula: (Sahay, 2008) [7].

$$\text{Field efficiency} = \frac{Effiective\ Field\ Capacity}{Theoretical\ Field\ Capacity} \times 100$$

Result and Discussion

The developed mini tractor operated mulch laying machine with fertilizer unit was evaluated. The Design Expert 13 software

(Trial Version), used for the experiment runs were reduced. The field testing of the mulch laying machine with fertilizer unit was carried out as per RSM using the BBD design model for experiment runs in a randomised manner. The results of the trials were discussed below.

The performance of the developed machine was evaluated at speed of operation (2, 3, 4 km/h) to study their effect on thickness of soil cover, width of soil cover, field capacity and field efficiency. The effect on selected independent parameters, individually was discussed in section 3.1 through 3.4.

Effect of speed of operation on thickness of soil cover

The effect of speed of operation on thickness of soil cover represented in figure 3.1. The thickness of soil cover was observed to be maximum, i.e., 4 cm at speed of operation 2 km/h. The thickness of soil cover was observed to be minimum, i.e., 3.2 cm at speed of operation 5 km/h. It was observed that the thickness of soil cover increases with decreasing speed of operation. It might be due to, at low-speed soil gets more time to collect the more soil for covering mulch paper.

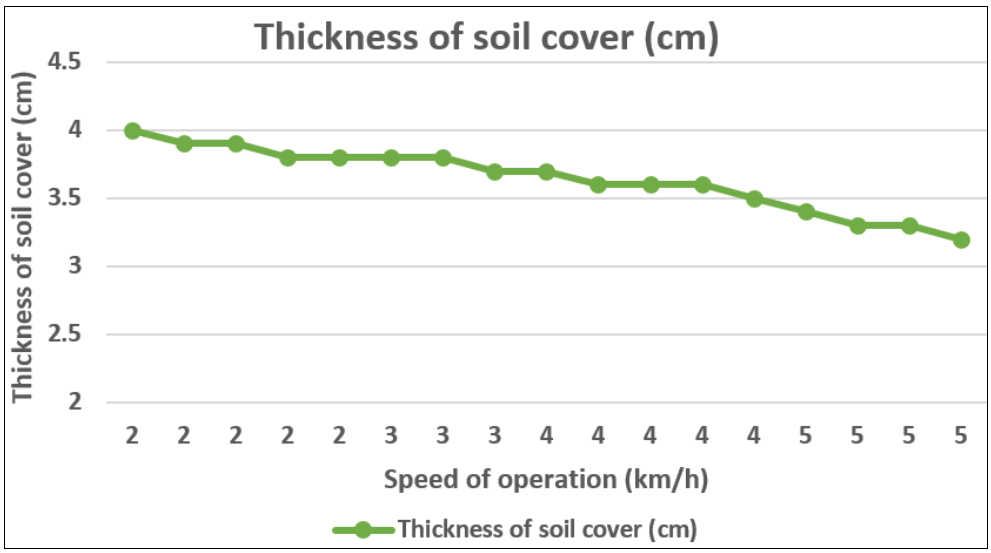

Fig 1: Effect of speed of operation on thickness of soil cover

Effect of speed of operation on width of soil cover

The effect of speed of operation on width of soil cover represented in figure 3.2. The maximum width of soil cover was recorded, i.e., 17 cm at speed of operation 2 km/h. The minimum width of soil cover was recorded, i.e., 13 cm at speed of operation 5 km/h. The results shown that, the speed of operation increases width of soil cover decreases. It showed that at low-speed machine gets more time to collect soil for covering the maximum width of mulch paper.

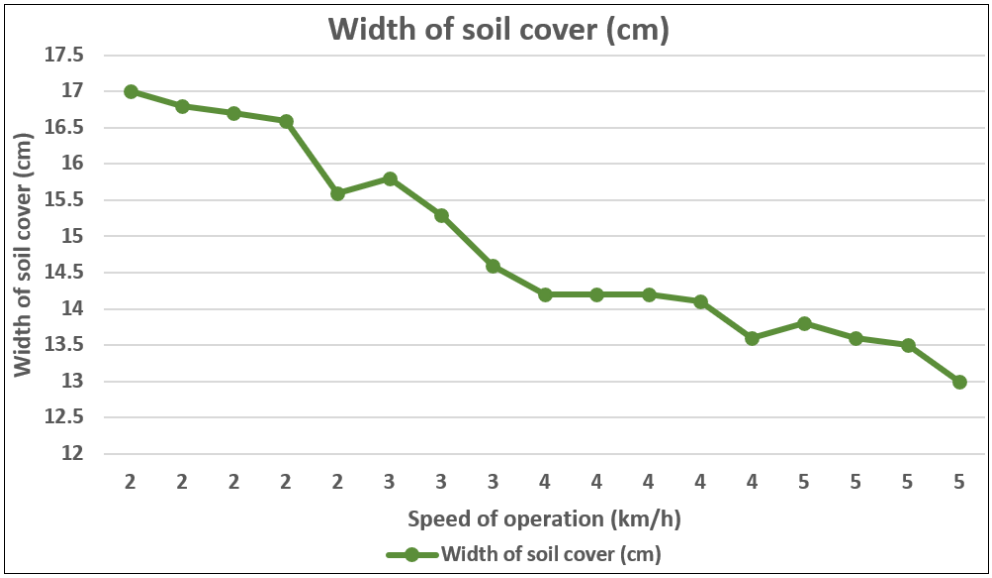

Fig 2: Effect of speed of operation on width of soil cover

Effect of speed of operation on field capacity

The effect of speed of operation on field capacity represented in figure 3.3. The width of soil cover was recorded maximum, i.e., 0.71 ha/h at speed of operation 5 km/h. The width of soil cover was recorded minimum, i.e., 0.23 ha/h at speed of operation 2 km/h. It was also observed that as the speed of operation increased, the field capacity was also seem to be increased. This may be because of productive time decreases.

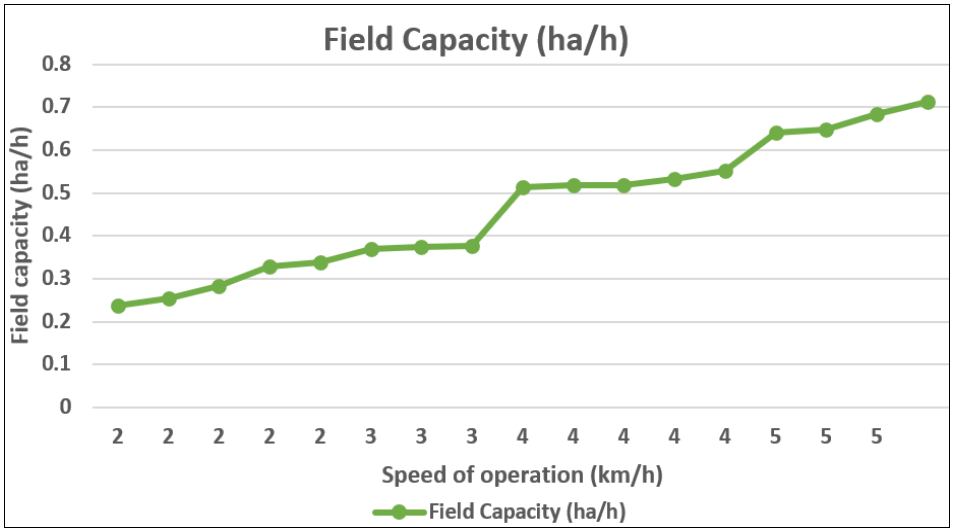

Fig 3: Effect of speed of operation on field capacity

Effect of speed of operation on field efficiency

The effect of speed of operation on field efficiency represented in figure 3.4. The maximum field efficiency was recorded, i.e., 94 percent at speed of operation 5 km/h. The minimum field efficiency was recorded, i.e., 73 percent at speed of operation 2 km/h. The results shown as, the speed of operation increases field efficiency increases.

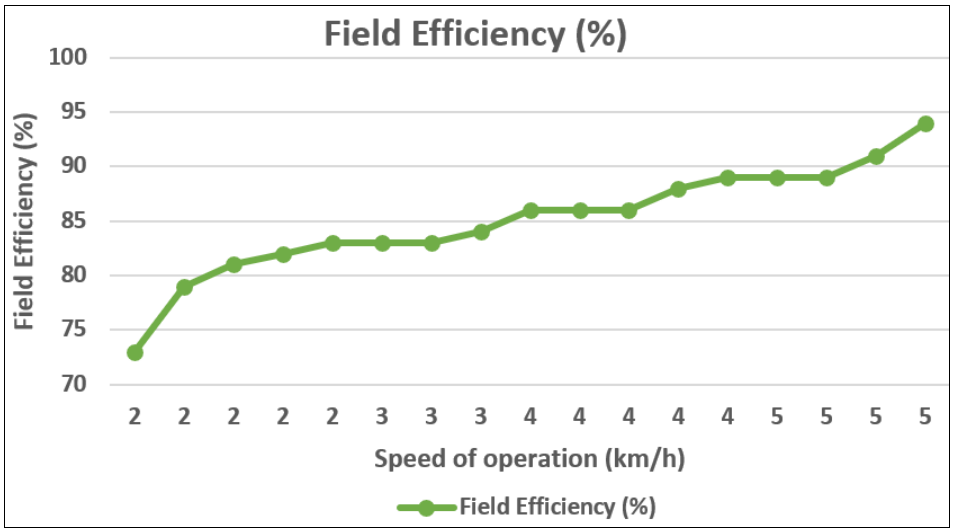

Fig 4: Effect of speed of operation on field capacity

Conclusion

Agriculture relied heavily on traditional methods and was largely dependent on the environment. However, new technologies have increased productivity and yields, leading farmers to seek new methods for increased profits. In present, mulch laying machine with fertilizer unit was developed and its performance was evaluated. The results of soil parameters concluded that, the moisture content of soil 20.4 percent, bulk density of soil 1.27 g/cm^3 and soil pulverization index 1.7 mm. The performance results concluded that, decreasing the speed of operation allows the equipment to disturb and move more soil, which results in an increases layer of soil thickness and width of the soil cover. The field capacity and field efficiency increase with higher operational speeds and improves overall productive time and reduce the non-effective time per hectare.

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