Print ISSN : 0972-8813
e-ISSN : 2582-2780

[Vol. 19(1), January-April, 2021]

Pantnagar Journal of Research

(Formerly International Journal of Basic and Applied Agricultural Research ISSN : 2349-8765)

G.B. Pant University of Agriculture & Technology, Pantnagar

PANTNAGAR JOURNAL OF RESEARCH

Vol. 19(1) January-April, 2021

CONTENTS

Performance evaluation of bullock drawn plastic mulch cum drip lateral laying machine

A. V. KOTHIYA[1], A. M. MONPARA[2] and B. K. YADUVANSHI[3]

[1,2]*Department of Farm Machinery and Power Engineering, College of Agricultural Engineering and Technology, Anand Agricultural University, Godhra-389001, [3]Polytechnic in Agricultural Engineering, Anand Agricultural University, Dahod-389151(Gujarat)*

ABSTRACT: Plastic mulch sheet has shown significant effect over farming technique. It has several advantages like weed control, moisture conservation, yield enhancement etc. Now a days drip irrigation is become necessity. When mulching is practiced along with drip irrigation, provides best results. At present, farmers have to lay the drip line and mulching sheet manually. To provide a better option, a plastic mulch cum drip lateral laying machine was developed at PAE, AAU, Dahod for the small farmers. The performance of the machine wasevaluated by determining the draft, power requirement, theoretical field capacity, effective field capacity, field efficiency, punching uniformity, punching efficiency and mulch sheet covering.Machine was tested at two levels of mulch width 0.75 m & 1.20 m and three levels of thickness (25, 30, 40 µm). The results were analysed statistically using factorial randomize block design. Average forward speed of developed machine was found as 1.98 km/h. Draft and power requirement were 29.14 kgf and 0.229 hp, respectively for 0.75 m widthand 25 µm thickness of plastic sheet.Maximum theoretical field capacity (0.292 ha/h)and field efficiency (52.98%)were found for the width of 1.20 and 075 m, respectively with plastic sheet thickness 25µm.The punching efficiency of the machine was found as 98% in the mulch thickness of 25 µm. The punching uniformity of the machine was found as 91.89 %in the mulch thickness of 25 µm. The amount of soil per meter length of the mulch sheet edge was found as 10.06 kg.

Key words*:* Draft, field capacity, mulch laying machine, performance evaluation

In any agricultural crop production, system human, draught animals and engines or motors provide the motive power in various proportions for crop production, harvesting, transport and processing. Draught animal is a reliable and popular farm power source in most developing countries. With the modernization of agriculture, the use of mechanical power in agriculture has increased but draught animal power continues to be used on Indian farms due to small land holdings and hill agriculture.

Agricultural productivity is linked with the availability of farm power. Bullocks meet power requirement of marginal and small farms (less than 2 ha) India has a large population of draught animals and bullocks are main draught animals in the country. Generally, draught animals are used for tillage, seeding, inter cultural and transportation. Bullock is one of the cheapest sources of draught power for all kinds of agricultural operations in villages in of Gujarat because large agricultural machines like tractor and power tiller are neither feasible nor economically viable due to poor financial condition of farmers and fragmented land holdings. India has 83 million of draft animal hence the further prospect of Indian farming largely depends upon the utilization of animal power through different matching implements for efficient work by accepting the ways of farm mechanization. It helps in reducing the cost of cultivation or operation and time saving. Farm mechanization is necessary to increase production with less investment and less time of operation.

Research studies have shown, when mulching is practiced along with drip irrigation, it gives best results. Plastic mulching sheet retains soil moisture and prohibits weed growth at the same also maintaining soil temperature. Even though this technology is quite old and versatile, its use is still limited due to difficulty of laying mulch, drip laterals and punching hole at the required spacing. This is because lack of availability of skilled labour and high labour cost. Bullock drawn machine may be more useful for the small-scale farmers who are concentration on high yielding variety crops.

A few number of tractor drawn mulch laying machine have been developed by different local manufacturer. However, it is very costly about Rs 50000-60000. So, these machines are not popular in small and marginal farmer. Still today, a large number of farmers are laying the drip line and mulching sheet manually. For laying, the drip line and mulching sheet requires lots of labours because both operations done separately one after another which increase labour requirement and cost of operations. These problems may be resolved by developing low cost implements for operations of drip laterals and mulch laying. For the small and marginal farmer it will suitable because of low cost technology and availability of bullock. Looking to the above fact the bullock drawn plastic mulch cum drip lateral laying machine was developed and performance evaluation was carried out.

MATERIALS AND METHODS

Location of experiment

Bullock drawn plastic mulch cum drip lateral laying machine was developed in the department of Farm Machinery and Power. The experiments were conducted at Polytechnic in Agricultural Engineering, AAU, Muvaliya Farm, Dahod, year 2017-19. The Latitude, longitude and altitude of experimental area is 22.83° N, 74.26° E and 311 m, respectively. The region is characterized by semi-arid climate with cold winter, hot and dry summer. The type of soil is black soil. It was connected with the approach road for transportation of machine to the field.

Working of the bullock drawn mulch sheet cum driplaying machine

When the developed machine was operated on the field, one end of drip line was initially fixed at ground. When machine was moved in forward direction, drip line was started to unwind and laid on the soil bed. Drip line was initially passed through the drip line guide wheel and laid on the soil below mulch sheet. Drip roll can be used up to length of 400 m. Simultaneously, as the machine move forward, the mulch sheet was pressed by press wheel and started to lay on the soil beds over the drip line. Mulch sheet is covered by soil through soil covering plates. Both sides of mulch sheet are covered by soil up to a width of 15 cm. Height of the soil covering plates can be adjusted according to soil requirement to cover the much sheet. Width of operation can be adjusted according to width of mulch sheet, which may vary from 0.6 m to 1.2 m. Holes were made by punching mechanism at required spacing on mulch sheet. Spacing of holes can be changed according to crop requirement by changing the position of pegs on periphery of punching wheel. These operations were also observed by Siddesh and Veerangouda (2017), Tipayale*et al.* (2017), Sutar *et al.* (2017) and Gowd and Prasad (2017).

Performance evaluation of developed bullock drawn plastic mulch cum drip lateral laying machine

Following observations were taken during field performance test of developed machine.

Observations

1. Mean mass diameter of soil

The mean mass diameter (MMD) of the soil aggregates is considered as index of soil pulverization and it can be determined by the sieve analysis of the soil sample through a set of standard test sieves (IS: 460-1982). Sieve provides a simple means for measuring the range of clod size and relative amount of soil in each size class. For this, the soil sample collected was passed through a set of sieves and weighing the soil retained on the largest aperture sieve, passed through each sieve and retained on the next sieve and passed through the smallest aperture sieve was done (Mehta *et al*., 1995). MMD was calculated by using following formula.

$$MMD = \frac{A+1.4B+2C+2.83D+4.76E+NF}{W} \quad .....(1)$$

Where,

MMD = Mean mass diameter of clod, mm

W = A+B+C+D+E+F, kg

N = mean of measured diameter of colds retained on the largest aperture sieve, mm

2. Soil moisture content

Moisture content for soil was computed on dry basis. Soil samples were collected from 0 to 15 cm depth of soil surface before operations for determination of moisture content and bulk density. The moisture content was determined in the laboratory by oven dry method and the samples were collected by core cutter from the soil. Four samples were collected randomly from test plots. The samples were kept in oven for 24 hours at temperature of 105°C. The samples were weighed before and after drying. Moisture content (dry basis) of soil was calculated by using following formula.

$$m.c = \frac{m_w - m_d}{m_d} \times 100 \quad .....(2)$$

Where,

m.c = Moisture content of soil, %db

m_w = Mass of wet soil, g

m_d = Mass of oven dried soil, g

3. Bulk density of soil

A standard core cutter was used to take sample from field having 100 mm diameter and 128 mm length. The samples were weighed and dry weights of the samples were calculated from the moisture content (dry basis). The ratio of dry weight of soil to the volume gave the bulk density. Bulk density of soil was calculated by using following formula.

$$\rho = \frac{m}{v} \quad ......(3)$$

Where,

ρ = Bulk density, g/cm^3

m = Mass of oven dried soil, g

v = Volume of core sampler, cm^3

4. Speed of operation

Speed of operation was calculated as time required to cover the distance of 30 m. Time was recorded using stop watch.

$$Speed\ (km/h) = \frac{3.6 \times Distance\ (m)}{Time\ (s)} \quad ......(4)$$

Field performance evaluation of the developed machine

Bullock drawn plastic mulch sheet cum drip laying machine was tested in rectangular experimental plot having area of 35 × 35 m^2. Field was prepared by two pass of cultivator and one pass of rotavator. Soil beds were manually prepared according to agronomical requirement of crop. During field test two levels of width (0.75 and 1.2 m) and three levels thickness (25, 30 and 40 µm) of mulch sheet were used. Thus, beds were prepared with width of 50 cm and 80 cm. Height of beds was kept 10-15 cm. To evaluate the performance of the machine, 30 m of bed length was marked.

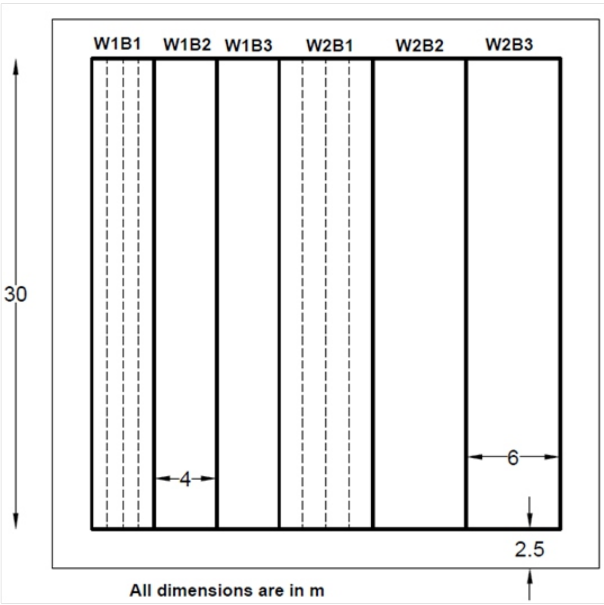

Fig. 1 Layout of experimental field

1. Draft requirement

Draft is defined as the horizontal component of pull parallel to direction of motion. Draft was measured using spring dynamometer. Capacity of dynamometer was 50 kgf.Dynamometer was attached between yoke and beam of machine. Angle of pull was 28 with horizontal surface. Draft was calculated by using following formula(Sahay, 2010).

$$D = P\cos\theta \qquad \ldots\ldots (5)$$

Where,
D = Draft requirement, kgf
P = Pull, kgf
θ = Angle between line of pull and horizontal surface, degree

Table 1: Parameters forperformance evaluation of the machine

Variables	Parameters	Levels
Independent Parameters	Mulch width (m)	0.75 m (W1) and 1.2 m (W2)
	Mulch thickness (µm)	25 (B1), 30 (B2), and 40 (B3), µm
Dependent Parameters		Draft (kgf)
		Power requirement (hp)
		Field capacity (ha/h)
		Field efficiency (%)
Quality parameter		Punching uniformity
		Punching efficiency
		Mulch covering

2. Power requirement

It was calculated from the draft and speed of operation during field test using following relationship(Sahay, 2010).

$$\text{Power (hp)} = \frac{\text{Draft (kgf) x Speed (m/s)}}{75} \qquad \ldots\ldots(6)$$

3. Theoretical field capacity

The theoretical field capacity is the rate of field coverage that would be obtained if implements were performing its

Fig. 2: Laying of mulch and drip by developed machine

Fig. 3: Measurement of draft

function 100 per cent of the time at the rated speed and always covering 100 per cent of its rated width (Kepner *et al*., 2005).

$$TFC = \frac{W \times S}{10} \quad ......(7)$$

Where,
TFC = Theoretical field capacity, ha/h
w = Theoretical width of implement, m
s = Speed of operation, km/h

4. Effective field capacity

The actual field capacity is the actual average rate of coverage by the implement. The total time required to complete the operation was recorded and effective field capacity was calculated as follows (Kepner *et al*., 2005).

$$EFC = \frac{A}{T} \quad ......(8)$$

Where,
EFC = effective field capacity, h/ha
A = Actual area covered, ha
T = Effective time, h

5. Field efficiency

Field efficiency is the ratio of effective field capacity to theoretical field capacity. It is expressed in per cent.

$$\text{Field efficiency}(\%) = \frac{\text{Effective field capacity}}{\text{Theoretical field capacity}} \times 100...(9)$$

6. Punching efficiency

The number of complete punched hole was counted for 50 observations in each row. The punching efficiency was calculated in percentage by using the following formula:

Table 2: Mean values of draft for different width and thickness of mulch

	Draft Requirement (kgf)				CD	
	B1 (25 µm)	B2 (30 µm)	B3 (40 µm)	Avg.		
W1 (0.75 m)	29.14	29.80	31.12	30.02	**W**	0.87
W2 (1.20 m)	32.23	33.55	34.66	33.48	**B**	1.07
Avg.	30.68	31.68	32.89		**W x B**	NS

Table 3: Mean values of power for different width and thickness of mulch

	Power Requirement (hp)				CD	
	B1 (25 µm)	B2 (30 µm)	B3 (40 µm)	Avg.		
W1 (0.75 m)	0.229	0.229	0.231	0.230	**W**	NS
W2 (1.20 m)	0.232	0.234	0.239	0.235	**B**	NS
Avg.	0.231	0.232	0.235		**W x B**	NS

Table 4: Mean values of TFC for different width and thickness of mulch

	Theoretical field capacity (ha/h)				CD	
	B1 (25 µm)	B2 (30 µm)	B3 (40 µm)	Avg.		
W1 (0.75 m)	0.212	0.208	0.200	0.207	**W**	4.57E-03
W2 (1.20 m)	0.292	0.283	0.279	0.285	**B**	5.60E-03
Avg.	0.252	0.245	0.240		**W x B**	NS

Table 5:Mean values of EFC for different width and thickness of mulch

	Effective field capacity (ha/h)				CD	
	B1 (25 µm)	B2 (30 µm)	B3 (40 µm)	Avg.		
W1 (0.75 m)	0.112	0.108	0.104	0.108	**W**	2.30E-03
W2 (1.20 m)	0.150	0.146	0.142	0.146	**B**	2.81E-03
Avg.	0.131	0.127	0.123		**W x B**	NS

Table 6: Mean values of field efficiencyfor different width and thickness of mulch

	Field efficiency (%)				CD	
	B1 (25 µm)	B2 (30 µm)	B3 (40 µm)	Avg.		
W1 (0.75 m)	52.98	52.39	52.17	52.52	**W**	0.63
W2 (1.20 m)	51.52	51.46	50.77	51.25	**B**	NS
Avg.	52.25	51.93	51.47		**W x B**	NS

$$\text{Punching efficiency}(\%) = \frac{\text{No. of complete punched hole}}{\text{Number of observations}} \times 100 ...(10)$$

7. Punching uniformity

The spacing between two consecutive holes was measured for a length of 10 m run in each row. The average value was found out and the coefficient of uniformity was calculated by following formula. (Szekut *et al.*, 2016)

$$\text{Coefficient of uniformity}(\%) = \frac{(1-\Sigma|X-\overline{X}|)}{N\overline{X}} \times 100 .....(11)$$

Where,
X = Spacing between two consecutive holes (cm);
X= Theoretical spacing (cm); and
N = No. of holes.

8. Mulch sheet covering

Amount of soil per meter length on both edge of mulch sheet was calculated from the bulk density of soil and

Table 7: Effect of mulch sheet thickness on punching efficiency

Thickness (μm)	No. of observations	No. of punched hole	Punching Efficiency (%)
25	50	49	98
30	50	49	98
40	50	47	94

volume of soil strip. Depth and width of the soil strip was measured and volume of soil calculated for a meter length. Amount of soil on mulch = Bulk density of soil × Volume of soil srtip on mulch

RESULTS AND DISCUSSION

Results of field observations

The selected field in the B-block was prepared for proper pulverization by two pass of cultivator and one pass of rotavator. As the soil type of the field was black soil, the smooth finish of the bed could not be achieved. However, it was fine enough to be gathered by mulch covering plates.

1. Mean Mass Diameter of Soil

One kg of soil sample was taken for sieve analysis of soil. It was passed through sieves having aperture size of 4.76, 2.83, 2, 1.41 and 1 mm. MMD of soil was found 17.59 mm.

2. Moisture Content of Soil

Soil samples were taken from the field at five different location of the experimental field up to 15 cm depth from the surface. The average moisture content of soil was found 14.47 per cent on dry basis.

3. Bulk Density of Soil

Bulk density of the soil was measured by core cutter having inner diameter of 100 mm and length of 128 mm. Soil samples were taken up to the depth of 15 cm. The samples were initially weighed before placing into hot air oven for 24 hours at 105°C. After drying, the weight of samples was again measured. Average values of bulk density were observed as 1.27 g/cc for experimental field.

4. Speed of Operation

Speed of operation was calculated by observing the time required to cover the distance of 30 m. Time was recorded using stop watch. The average value of the speed was found 1.98 km/h.

Performance evaluation of developed machine

Bullock drawn plastic mulch sheet cum drip laying machine was tested in square experimental plot having area of 35 × 35 m^2. Soil beds were manually prepared according to agronomical requirement of crops. During field test two levels of width (0.75 and 1.2 m) and three levels thickness (25, 30 and 40 μm) of mulch sheet were used. Thus, beds were prepared by taking width of 50 cm and 80 cm, Height of beds was kept 10-15 cm. To evaluate the performance of the machine, 30 m length of bed was marked. Statistical analysis was carried out using factorial randomized block design (FRBD) (Panse *et al*., 1967).

1. Effect of Width and Thickness of Mulch onDraft Requirement

The soil covering plates operates in sliding action and shares major draft required to pull the machine. The draft required to operate the developed machine was calculated from the measured values of pull. The developed machine was tested at two levels of mulch width as W1 (0.75 m) & W2 (1.20 m) and three levels of thickness B1 (25 μm), B2 and B3 (40 μm). The values of the draft of different levels are shown in Table 2.

The draft of developed machine was found as for W1 and B1, B2 and B3 as 29.14 kgf, 29.80kgf and 31.12 kgf, respectively. The draft of developed machine was found for W2 and B1, B2 and B3 as 32.33 kgf, 33.15kgf and 34.66 kgf, respectively. The minimum draft was found for W1 and B1 as 29.14 kgf and maximum for W2 and B3 as 34.66 kgf. The mean values of the draft of different levels are shown in Table 2. The graphical representations of mean values of the draft are shown in Fig 4. Results were analyzed statistically; it shows that width had a significant effect on the draft at 5 per cent level of significance. The results show that draft of the developed machine increases with increase in mulch width. This is because weight of the mulch roll increases as width increases and more force require unwinding longer mulch roll. However, this effect of weight will theoretically reduce in proportion of remaining mulch sheet on much roll carrier. Hence, it will be zero at the time of finishing of mulch roll.

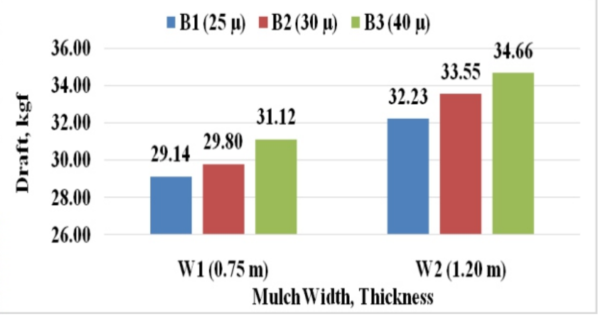

Fig. 4Effect of width and thickness of mulch sheet on draft

2. Effect of Width and Thickness of Mulch Sheet on Power Requirement

The power required to operate developed machine was calculated based on the basis of operating speed and the draft required to operate the machine.

The power of developed machine was ranged between W1, 0.229 to 0.231 hp and for W2,0.232 hp to 0.239 hp. The minimum power was found for W1 and B1 as 0.229 hp and maximum for W2 and B3 as 0.239 hp. The mean values of the power of different levels are shown in Table 3. The graphical representation of mean value of the power is shown in Fig. 5. Results were analyzed statistically and it shows that width and thickness of mulch sheet had no significant effect on the power requirement at 5 per cent level of significant.

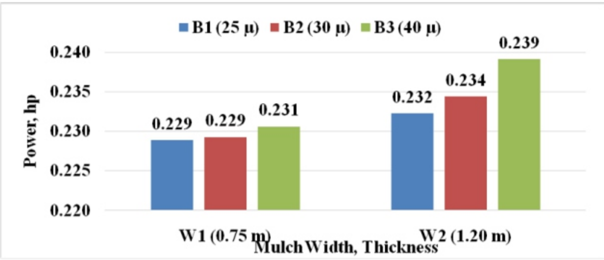

Fig. 5: Effect of width and thickness of mulch sheet on power

3. Effect of Width and Thickness of Mulch Sheet on TFC

The developed machine was tested at two levels of mulch width as W1 & W2 and three levels of thickness B1, B2and B3. The values of TFC are given in Table 4.

The values of TFC of were found forW1 and B1, B2and B3as 0.212 ha/h, 0.208 ha/h and 0.200 ha/h respectively. The values of TFC were found for W2 and B1, B2and B3as 0.292 ha/h, 0.283 ha/h and 0.279 ha/h, respectively. The minimum value of TFC was found for W1 and B3 as 0.200 ha/h and maximum for W2 and B1 as 0.292 ha/h. The graphical representation of mean values of the TFC under different operating conditions is shown in Fig. 6. Results were analyzed statistically and it shows that the width and thickness had a significant effect on the TFC at 5 per cent level of significant. The results show that TFC of the developed machine increases with increase in mulch width. This is because TFC is directly dependent on the working width of the machine.

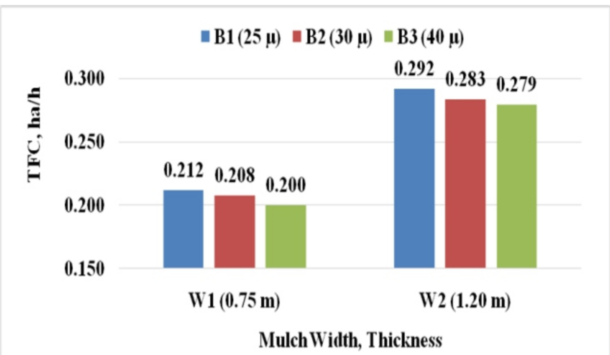

Fig. 6: Effect of width and thickness of mulch sheet on TFC

4. Effect of Width and Thickness of Mulch Sheet on EFC

The EFC of developed machine was calculated at two levels of mulch width as W1 & W2 and three levels of thickness B1, B2 and B3.

The values of EFC were found for W1 and B1, B2 and B3 as 0.212 ha/h, 0.208 ha/h and 0.200 ha/h, respectively. The values of EFC were found for W2 and B1, B2 and B3 as 0.92 ha/h, 0.283 ha/h and 0.279 ha/h, respectively. The minimum EFC was found for W1 and B3 as 0.104 ha/h and maximum for W2 and B1 as 0.150 ha/h. The values of EFC for different width and thickness are shown graphically in Fig.7. Results were analyzed statistically and it shows that width had a significant effect on the EFC at 5 per cent level of significant. The results show that EFC of the developed machine increases with increase in mulch width.

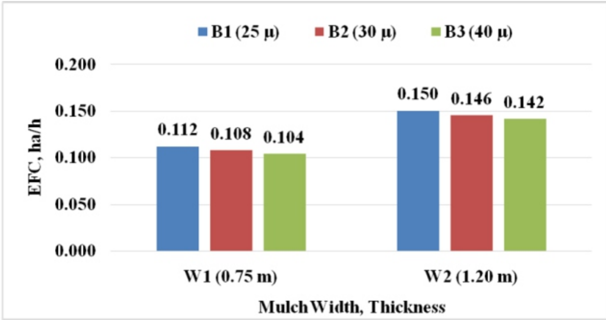

Fig. 7: Effect of width and thickness of mulch sheet on EFC

5. Effect of Width and Thickness of Mulch Sheet on Field Efficiency

The field efficiency of the developed machine was calculated at two levels of mulch width as W1 & W2 and three levels of thickness B1, B2 and B3. The observed values of field efficiency are presented in Table 6.

The field efficiency of machine under W1 for B1, B2 and B3 was found as 52.98 per cent, 52.39 per cent and 52.17 per cent, respectively, similarly, under W2 for B1, B2 and

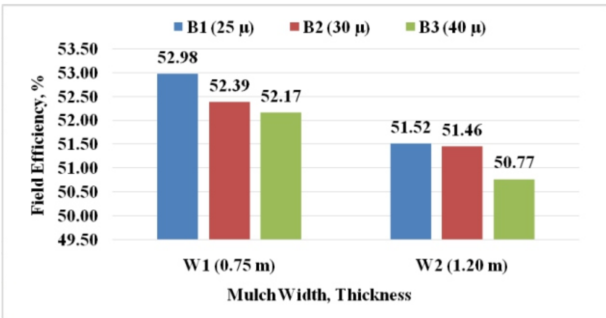

Fig. 8: Effect of width and thickness of mulch sheet on field efficiency

B3 as 51.52 per cent, 51.46 per cent and 50.77 per cent, respectively (Table 6). The minimum value field efficiency was found for W2 and B3 as 50.77 per cent and maximum for W1 and B1 as 52.98 per cent. The graphical representation of values of the field efficiency is shown in Fig. 8. Results were analyzed statistically and it shows that width had a significant effect on the field efficiency at 5 per cent level of significant. The results show that field efficiency of the developed machine increase with increase in mulch width.

6. Punching Efficiency

The punching efficiency of the machine was found as 98, 98 and 94 per cent in the mulch thickness of 25, 30 and 40 µm respectively. The average values from the observed data are presented Table 7.

7. Punching Uniformity

The punching uniformity of the machine was found as 91.89, 91.56 and 90.78 per cent in the mulch thickness of 25, 30 and 40 µm respectively.

8. Mulch sheet covering

The amount of soil per meter length on both the sides of mulch sheet up to 15 cm covering width was found as 10.06 kg.

CONCLUSION

The developed machine can be used to lay mulch sheet and drip line simultaneously and holes can be made on mulch sheet at variable spacing. Width of operation can be adjusted for different width of mulch sheet varying between 0.6 m to 1.2 m. Height of soil covering plates and drip guide can be also adjusted according to height of soil beds. Mulch sheet was laid properly and both sides of the mulch sheet was covered with soil strip up to a width 15 cm in soil condition like MMD of soil 17.59 mm, moisture content 14.47 on dry basis and bulk density of soil 1.27 g/cc.The developed machine was tested at two levels of mulch width W1 (0.75 m)& W2 (1.20 m) and three levels of thickness B1 (25 µm), B2 (30 µm) and B3 (40 µm). The average forward speed of developed machine was found as 1.98 km/h. Draft of machine increases as width and thickness of mulch increases. The draft and power was found in the range of 29.14 to 34.66 kgf and 0.229 hp to 0.239 hp, respectively. Power requirement of the developed machine was not change significantly for width and thickness of mulch. The TFC of the developed machine increases as width increases and decreases as thickness of mulch increases. The value of TFC and EFC was found in the range of 0.200 ha/h to 0.292 ha/h and 0.104 ha/h to 0.150 ha/h, respectively. The EFC of the developed machine increases as increase in mulch width and decreases as thickness of mulch increases.Field efficiency of the developed machine decrease with increase in mulch width. The value of field efficiency was found in the range of 50.77 to 52.98 per cent. The punching efficiency and punching uniformity of the machine was found as 98, 98 and 94 per cent and 91.89, 91.56 and 90.78 per cent for the mulch thickness of 25, 30 and 40 µm, respectively. The amount of soil per meter length of the mulch sheet edge was found as 10.06 kg. The overall performance of the machine was found satisfactorily.

REFERENCES

Gowd, C. M. and Prasad, B. (2017). Design and development of plastic mulch laying machine in agriculture. *International Journal of Technical Innovation in Modern Engineering and*Science, 3(11): 97-100.

Kepner, R. A., Bainer, R. and Barger, E. L. (2005). Principles of Farm Machinery. CBS Publishing Company, New Delhi,Pp. 24-29.

Mehta, M. L., Verma, S. M., Mishra, S. K. and Sharma, V. K. (1995).*Testing and Evaluation of Agricultural Machinery.*National Agricultural Technology Information Centre, Ludhiana,Pp. 57 -68.

Panse, V. G. and Sukhatme, P. V. (1967). *Statistical Methods for Agricultural Workers*. Indian Council of Agricultural Research, New Delhi.

Sahay, J., (2010). Elements of Agricultural Engineering (4th ed.,Reprint,2010).Delhi: Standard Pubishers Distributors.

Siddesh, M. and Veerangouda, M. (2017). Development and evaluation of tractor operated plastic mulch laying equipment. *International Journal of Agricultural Engineering*, 10(2): 374-378.

Sutar, S., Yamgar, R., Patil, P., Bhosale, S. and Siddha, U. Y. (2017). Advanced mulching paper and drip laying machine. *Imperial Journal of Interdisciplinary Research*, 3(10): 534-536. http://www.onlinejournal.in

Szekut, F. D., dos Santos, D. B., de Azevedo, C. A. V., Klein, M. R., Ribeiro, M. D. and de Sousa Medeiros, S. (2016). Biofouling and performance of labyrinth-type emitters in drip irrigation with treated domestic sewage. *African Journal of Agricultural Research*, 11(39): 3839-3846.

Tipayale, A., Salunnke, M. S., Thete, S. U., Thete, T. S. and Thete, S. B. (2017). Advance mulching paper laying machine. *International Journal for Scientific Research & Development*,5(3): 217-219.

Received: February 20, 2021
Accepted: April27, 2021