A TRACTOR MOUNTED IMPLEMENT FOR PLASTIC FILM LAYING ON CULTIVATED SOIL AND RAISED SEED BED

Mohd Fazly Mail
Engineering Research Center
Malaysian Agricultural Research and Development Institute (MARDI),
43400 Serdang, Selangor, Malaysia
Email: fazlym@mardi.gov.my

Hafidha Azmon
Engineering Research Center
Malaysian Agricultural Research and Development Institute (MARDI),
43400 Serdang, Selangor, Malaysia
Email: hafidha@mardi.gov.my

Mohd Shahmihaizan Mat Jusoh
Engineering Research Center
Malaysian Agricultural Research and Development Institute (MARDI),
43400 Serdang, Selangor, Malaysia
Email: shahmi@mardi.gov.my

Mohd Zubir Idris
Engineering Research Center
Malaysian Agricultural Research and Development Institute (MARDI),
43400 Serdang, Selangor, Malaysia
Email: mzubir@mardi.gov.my

Mohd Nadzim Nordin
Engineering Research Center
Malaysian Agricultural Research and Development Institute (MARDI),
43400 Serdang, Selangor, Malaysia
Email: mnadzim@mardi.gov.my

Mohd Shahril Shah Mohamad Ghazali
Engineering Research Centre (ER)
Malaysia Agricultural Research and Development Institute (MARDI)
13200 Kepala Batas, Pulau Pinang, Malaysia
Email: shahril@mardi.gov.my

ABSTRACT

The aim of this study is to explore the performance and operation of a plastic film laying machine. They were conducted in light of the need for mechanized plastic mulch laying operations due to a lack of labor force. Tests were carried out on mineral soil at MARDI Serdang and tin-tailed soil at MARDI Kundang Research Station. The applicator is well performed and satisfactory for use in dry, brittle mineral and tin-tailed soil conditions. However, when applied to moist soil or plastic clay loam, it is not satisfactory. This applicator consists of a mechanism for placing a plastic mulch, a compacter, a roller and two discs closer to the furrow. Current practices were done manually by workers which were tedious and tiring process. Only two or three rows can be completed by two workers to lay plastics mulching on the ground for along a 50m per day. The results of the performance test showed that the field efficiency was 84 percent. Averagely, 130s were recorded for the machine to install the plastic mulching along the 50m planting bed. As a result, it has been shown that plastic mulching machines can be more effective than traditional for upscaling purposes. Compared to the traditional method, the implement could have saved 93 - 96 percent of the labour required for the same process.

Key words: plastic mulching machine, labour shortage, functional performance, field performances, field efficiency

INTRODUCTION

Mulching is a practice to conserve soil moisture, control weed infestation, moderate soil temperature and provide the plant with a microclimate (Veer et al. 2017). Covering mulch sheet over a raised bed give benefit on plant growth because there is an effect of salt content alteration in soil which needed by the plant (Sun Xiaoren, 1991). The black colour of plastic mulch is commonly used by farmers in open field plantation. Black sheet plastic can block the sunlight and avoid the emergence of the weeds that usually appear around the cultivated crop (Siddesh, et al., 2018; Lamont, 2017). Plastic mulch laying on the raised bed, can conserve the moisture of soil and reduce the loss of nutrient and fertilizer given to the crop since leaching can be minimized (Scott and Gilead, 1995).

Most of the silver shine plastic mulch film used in Malaysia is 4mm thick and 1.2m wide and come on rolls 200m long. The width of the plastic mulch may vary from 0.9m to 1.5m, depending on the crop and cropping system. Commercially, by using 1.2m wide of plastic mulch film, the planting bed is normally ranging from 0.85m to 0.9m as the remaining width was buried at the edge of the planting bed. The plastic mulch comes with silver and black color front and back. In order to avoid overheating of seedlings, crops and fruits, the silver color reflects radiation, promotes photosynthesis and repels pests, and the black color prevents light from entering and decreases weed germination.

Competition for agricultural land and labour is a major challenge for the agricultural industry. The traditional method of laying plastic mulch is a labour-intensive, time-consuming method that causes health problems (Adil, 2020). The work done manually by labours shows low quality of proper laid plastic mulch on the raised bed due to the tearing sheet during handling, difficulty in covering the bed and disturbances of wind during operation even though there are four labours involved in this activity (Omprabha et al., 2019).

There is a need to reduce labour shortages and production costs for upscale vegetable production. Mechanization is a way to do that. The conventional method of laying plastic mulch on a raised bed is economical for small-scale production but not practical for large-scale planting. Plastic mulches are laid before planting and are widely used in vegetable planting to control weed growth, reduce soil moisture loss and prevent soil erosion (A.V. Rangbhal, 2018).

The conventional method for the installation of plastic mulch involves several tasks such as rolling the plastic mulch and covering the plastic mulch with soil on both sides (Figure 1a). The plastic mulch must be neatly placed on the ground without blowing away (Figure 1b). The plastic mulching machine is currently not popularly used in Malaysia and there is no published report on its performance under local conditions. Given the current need for mechanization of vegetable production, this information would be very useful. Most of the available techniques are effective for performing tasks such as laying mulch. There are integrated machines that can perform plastic mulch laying, drip irrigation installation and transplanting on the planting bed at one time, but they are either expensive or too large to operate in small-scale farms that are not reliable for the country of Malaysia. This article outlines the working concept, field performance and prospects of a plastic film laying machine on cultivated soil and raised seedbed.

Under the RMK 11th budget, research has been carried out to increase the production of cabbage in lowland areas due to a decrease in the planting area in Cameron Highland affecting the production of cabbage (Department of Agriculture, 2016). Cabbage (Brassica oleracea var capitata) is a temperate vegetable crop commercially grown in low-temperature highlands (Cameron Highland, Kundasang and Ranau) mainly exported to Singapore (Department of Agriculture, 2016). In order to ensure adequate supplies in the country, cabbage is imported from China and Indonesia (Federal Agricultural Marketing Authority, 2014).

Therefore, the present study attempted to evaluate the performance of plastic mulch film laying machine on cultivated soil and raised seed beds with tractor-mounted to overcome the labor issue. A plastic mulch film laying machine without the use of complicated mechanical technologies is highly desirable.

Figure 1 (a): Operators are laying the plastic mulch film on the raised bed; (b) Operators need to bury the plastic mulch film at the edge of a planting bed

(a) (b)

MATERIALS AND METHODS

The plastic mulching machine (Figure 2) is a semi-mounted tractor implement. It consists of a steel frame, axle for laying plastic mulching, furrow closer, and two ground wheels, two-disc coulters, a power transmission system and a three-point hitch headstock. As the implement is pulled along the planting rows by the tractor, the implement is mounted together plastic mulching mechanism. The soil needs to be rotor before the plastic mulch installation to ensure that the soil is finely tilted. The working principle of the plastic mulch laying machine is based on two ground wheels on both sides push the plastic mulching to the ground, while the disc coulters cover the edge of the plastic mulching with the soil. The plastic mulcher is driven by the PTO shaft of the tractor through the gearbox and driveshaft system.

The black silver colour of plastic mulch roll with 1.2meter wide and 4mm thick is used with the mulch machine. The width of the plastic mulch is chosen on the basis of the width of the raised bed of the crop. In this study, 0.9m beds were prepared for one row plantation of cabbage.

The machine mechanical functioning of the plastic mulching machine components was observed without taking any work rate data. Observations were made on the implement's ease of operation, turning at the headland, plastic film axle roller, the height of the machine from the raised bed, furrow closer, two ground wheels and working speeds. The observations on operational functional performance were made on the forward speeds suitable for the mineral soil and tin-tailing soil and were repeated several times to get the optimum speed and for the ease of operator in handling the equipment.

The plastic mulch laying machine was functionally carried out on mineral soil at the MARDI Serdang and tin-tailed soil at the MARDI Kundang Research Station. The raised beds were prepared for lowland cabbage at a 0.90m between rows as the width of the 44-HP tractor (center tire to center tire) is 1.2m. Observations were made and data were collected while the implement was operated in the field doing the various tasks. Total time taken to complete installed the plastic film on the planting bed for each row over the whole plot, total time taken for stoppages due to implement breakdown or mishandling of the machine and total time taken for turning at the end of the rows were recorded.

The speed of operation was measured by recording the time required to cover the distance in the field during operation by using Equation 1.

$$S = \frac{d}{t} \times 3.6 \qquad \text{(Equation 1)}$$

Where:
S= Speed of operation (km/hr)
d = distance travelled (m)
t = time (s)

The theoretical field capacity was calculated without considering the time losses during operation by following Equation 2.

$$TFC = \frac{W \times S}{10} \qquad \text{(Equation 2)}$$

Where,
TFC = theoretical field capacity,
W = the width between-row spacing (m),
S = speed of operation (km/hr).

Time losses during operation such as turning at the end of rows, mishandling and repairing implement breakdown were considered to calculate the effective field capacity. The field efficiency is the ratio of effective field capacity to the theoretical field capacity and is normally expressed in percent as mentioned in Equation 3.

$$FE = \frac{EFC}{TFC} \times 100 \qquad \text{(Equation 3)}$$

Where,
EFC = effective field capacity which is the work rate achieved over the whole plot with considering the total time taken for the work done at the plot,
FE = the field efficiency of the implement under real conditions.

Figure 2: Overall view of the plastic mulching machine

RESULTS AND DISCUSSION

Functional performance

The plastic mulching machine has been tested at the MARDI Research Station in Serdang and Kundang. Test plots were areas of clay loam soil with a flat to gently rolling topography (0-3 degree gradient). The soil of the test sites is generally similar to those found in areas where the vegetable is commercially produced. The test plots were planted with a heat-tolerant variety of cabbage (F1 311 All Seasons) at a 0.90 meter distance between rows with one row planter. The crop rows in the plots were between 97 to 100 meters long. The implement was operated using a 44Hp two-wheels-driven agricultural tractor operated with a 'Low-2' gear position, a 1900 rpm engine speed and a 540 rpm PTO speed. Observations and data on the ease of operation and speed of operation of the implement have been collected.

Machine operation

The plastic mulcher worked very easily on the test plots. The attached rotovator helped the plastic mulcher to run efficiently. In dry and brittle soil conditions, the plastic mulch and the drip tape are easily placed on the planting beds. The soils dragged along the coulters to cover both sides of the plastic mulch. When soil conditions were moist or plastic, the installation of plastic mulch was not very effective. The soil stuck together and did not pass through the wheels of the ground. Instead, the ground wheels would roll as compact, and the plastic mulch would invariably be destroyed by the ground wheels.

The implement was not difficult to handle. The depth control ring at the disc coulter prevents the coulter blade from cutting heavy ground trash effectively. Without rings, the coulters worked better. Control of working depth was achieved with the three-point hitch system of the tractor.

Working speed and spot work rate

The forward speed of the tractor operating the implement ranged from 0.35 m/s to 0.43 m/s with a mean of 0.39 m/s. The corresponding mean spot work rate was estimated at 0.17 ha/h (0.15-0.19 ha/h) from the data.

Field performance

The field performance of the implement was evaluated include different sizes of land. During machine testing, the soil was dry and brittle. Tractor capacity and operation settings as well as crop planting arrangements and pre-harvest treatments used in field performance tests were similar to those used in functional tests. The total time taken to work on each plot was measured as well as the effective working time (i.e. actual time spent laying the plastic mulch) and the time taken to turn the headland. The overall work rate, field efficiency and labour use were estimated from the data (Table 1). Comparison summary of field performance findings for laying plastic film conducted manually and by using the plastic mulch film machine are presented in Table 2.

Table 1: Overall work rate, field efficiency and labour use of the plastic mulching machine

Plot size (ha)	Overall work rate (ha/h)	Field efficiency (%)	Labour use (man-h/ha)
0.28	0.16	80	6.25
0.06	0.18	82	5.56
0.12	0.17	83	5.88
0.13	0.19	88	5.26
0.15	0.19	89	5.26

Table 2: Comparison of field performance findings for laying plastic film

Parameters	Method of laying plastic film	
	Manual	Plastic mulching machine
Speed, km/h	0.082	1.404
Efficiency field capacity, ha/h	0.010	0.178
Field efficiency, %	--	84.4
Time required, h/ha	102.18	5.62

Prospect

Most parts of the system could be assembled locally and the necessary technology is within the capacity of local rural engineering workshops. Therefore, the prospect of producing the implement locally exists. The locally produced version could be cheaper than the imported ones during small-scale batch processing. The implication of using the plastic mulch film implement are in terms of time saving, labor cost saving, better ergonomic design, easier, faster and economic and most importantly is increase the productivity of the plantation. This machine will be very helpful to crop production industry, vegetable agropreneur, service providers, extension agencies and farmers.

CONCLUSION

In general, the performance of the plastic mulching machine on dry and friable clay loam soil was satisfactory. The machine can successfully plough, place drip tape and mulch plastic on the ground efficiently. Plasticulture is crucial to Malaysian agriculture, given the changing technological scenario for boosting crop yields and productivity. The introduction of this machine has brought about a revolution in the management of agriculture. Laying plastic mulch by machine was found to be average 0.178 ha/h. The field efficiency was calculated as 84.4 on average. The time saving over the conventional method of laying plastic much on a raised bed can reduce a lot of money spent on labour.

ACKNOWLEDGMENT

The author would like to thank Mr. Noraznal Mohd Zainal, Mr. Zulfadzli Marzuki, Mr. Zawayi Mat, Mr. Muhammad Hakimi Dzulkifli, Ms. Norahshekin Abd Rahman, Mr. Jambri Mahat, Mr. Othman Omar, Mr. Muhammad Ghazi Ahmad Zaini and Mr. Abdul Hakam Mohamed Ali for their assistance during modifications and field tests.

REFERENCES

A.V. Rangbhal, S.V. Pathak (2018). *Performance of Mechanical Plastic Mulch Laying Practices: A Review*, International Journal of Engineering Science Invention (IJESI), 7(3), 42-46

Adil Abdelsamia Meselhy (2020). *Development the Wide Ridges Machine for Laying Drip Irrigation Tubes and Plastic Mulch in Ras Sudr-South of Sinai*, International Journal of Applied Agricultural Sciences, 6(5), 135-147

Department of Agriculture (2016). *Vegetables and Cash Crops Statistic*, Ministry of Agriculture and Agro-based Industry, Malaysia

Lamont, W. J. (2017). *Plastic Mulches for the Production of Vegetable Crops. A Guide to the Manufacture, Performance, and Potential of Plastics in Agriculture*, Elsevier, 45–60. doi:10.1016/B978-0-08-102170-5.00003-8

Omprabha, VM Victor and Amita Gautam (2019). *Performance evaluation of animal drawn plastic mulch laying machine*, Journal of Pharmacognosy and Phytochemistry, 2, 280-283Scott G and Gilead D. (1995). *Degradable polymers: Principles and Applications.* Chapman and Hall, London, 187 - 189

Siddesh Marihonnappanavara, M. Veerangouda, K.V. Prakash, Sunil Shirwal and B. Maheshwara Babu (2018) *Performance Evaluation of Tractor Operated Plastic Mulch Laying Equipment for Black and Silver Colored Plastic Mulches*, International Journal of Current Microbiology and Applied Sciences (IJCMAS), 7(12), 2411-2422

Sun Xiaoren (1991). *A Study on Soil Temperature When Mulched by Transparent Plastic Film, Energy Conservation in Buildings,* Elsevier, 381-385, https://doi.org/10.1016/C2009-0-14771-2

The Federal Agricultural Marketing Authority (2014). *Main Marketing Statistics*, Ministry of Agriculture and Agro-based Industry, Malaysia.

V.P. Veer, P.R. Thete, D.A. Shinde, K.S. Vanve, S.D. Ratnakar (2017). *Mulching Paper and Drip Laying Machine*, International Journal of Science Technology Management and Research 2(3), 33-38