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Agro-economic evaluation of different weed control methods in rubber plantation

Phebe Joseph* and M.D. Jessy

Rubber Research Institute of India, Kottayam - 686 009, Kerala, India

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Abstract

The selection of the most suitable method of weed control has an important role in the efficient and economical control of weeds in rubber plantations. A comparative evaluation of work capacity, energy consumption, cost of operation and rate of weed regeneration (efficiency of weed control) of different weed control methods were studied in a field experiment at the Central Experiment Station of the Rubber Research Institute of India, Chethackal, Central Kerala. The weeding methods included slashing of weeds with sickle (manual weeding), spraying of herbicide (glyphosate 2 L ha^{-1}) and mechanical weeding by weed cutters. The results of the study revealed that there was significant difference in work capacity, energy consumption, cost of operation and rate of regeneration of weeds among different weed control methods. The highest work capacity of 16 h ha^{-1} was observed in the mechanical weed control whereas the energy consumption (38.03 MJ ha^{-1}) and rate of regeneration of weeds were the lowest in chemical weed control method. Compared to manual weeding, the cost comparison of different weed control methods showed that the weeding cost can be reduced by 65 and 75 per cent by chemical and mechanical weed control methods respectively. Considering the long term sustainability, environmental factors, scarcity of labourers and economics, mechanical weed control by weed cutters is the most suitable method for weed control in rubber plantations.

Keywords: Cost of weed control, rubber plantation, weed control methods, weed regeneration

Introduction

Weed management in rubber plantations has been a major problem, since the cost of labour and herbicide has increased. The control of weeds constitutes a major portion of the expenditure for cultural operations during the entire growth phase of rubber. The common methods adopted for weed control in rubber plantations include slashing by sickle (manual), herbicide spray (chemical) and mechanical weed control by weed cutters. Manual weeding is labour intensive and expensive. In rubber plantations 4 to 5 rounds of manual weeding is required per year for controlling weed growth. The use of herbicide is an easier and cheaper alternative. George *et al.* (2004) reported that the integrated weed control method of spraying glyphosate in the plant basin and slashing the weeds in the remaining area is the cost effective and eco-friendly method of weed management in rubber. Indiscriminate uses of herbicides lead to accumulation of chemical residue in the soil (Tejada *et al*., 1995) and develop herbicide resistance in plants (Cordill and Grift, 2011). Usage of mechanical devices like brush cutters/weed cutters are becoming more popular among rubber growers due to the increasing cost of labour and wide spread apprehension about the environmental impact of herbicides.

As a production oriented sector, agriculture requires energy as the most valuable input to production. It is invested directly for operating the machinery and equipment on the farm and indirectly in the production of fertilizers, pesticides, herbicides *etc*. Energy needed for agriculture production is about 3 per cent of the national consumption in developed countries and about 5 to 6 per cent in developing countries (Stout, 1989). The amount of

**Corresponding Author: phebe@rubberboard.org.in*

energy used in agricultural production, processing and distribution is increasing to feed the expanding population and to meet other social and economical goals. Sufficient availability of the energy and its effective and efficient use are prerequisites for improved agriculture production (Abubakar and Ahmad, 2010). Even though all weed control measures are effective in decreasing the total weed density, information regarding energy consumption, work capacity, rate of regeneration of weed flora and operation cost of weeding methods are not available so far. In this context, the present study was initiated to evaluate the performance and energy consumption of the different methods of weed control in rubber plantations.

Materials and methods

A field experiment was conducted in a mature rubber plantation at the Central Experiment Station of the Rubber Research Institute of India, Chethackal, Central Kerala (9°22'N; 76°50'E and 50 m above MSL) during the year 2012. The experiment was laid out in blocks. The treatments included slashing of weeds with sickle (manual weeding), spraying of herbicide (glyphosate 2 L ha^{-1}) and mechanical weeding by weed cutters. The plot size of each treatment was 1785 m^2. For each treatment, work capacity, energy consumption, cost of operation and rate of weed regeneration (efficiency of weed control) were measured. The work capacity was computed by measuring the time required for weeding per unit area (h ha^{-1}) and the energy consumption of different weed control measures were calculated by the method suggested by Firouzi and Alizadeh (2012).

The energy requirements associated with each weeding operations were computed by summing up the following unit requirements:

1. The energy contained in the machine and equipment (energy/time x time/area)
2. The fuel used (volume/time x time/area x energy/volume)
3. The energy input of the operators (energy/time x time/area)

The energy input of operators (manual) was evaluated according to Norman, 1978 as:

Male manual energy (EMm) = 0.75 Ta, MJ and

Female manual energy (EMf) = 0.68 Ta, MJ

where, 0.75 and 0.68 are the energy input of an average adult male and female respectively, (MJ h^{-1}).

Ta = Useful time spent by a male/female worker per unit operation, (h).

Mechanical (liquid fuel) energy was evaluated according to Pimentel, 1992 as:

Liquid fuel energy input for petrol (EF_{LP}) = 42.3 P, MJ

Where, 42.3 = Unit energy value of petrol, MJ L^{-1}

P = Amount of petrol consumed per unit operation, L

The most prominent weed species present in the experiment area was *Alternantera dentate*. Pre-treatment weed samples were collected and the treatments were imposed during February 2012. To assess the regeneration of weeds, representative weed samples were collected 30, 45, 60, 75 and 90 days after the imposition of treatments from each plot using a quadrate of 0.5 m^2, dried and expressed as dry weight per m^2. The dry weight of weeds during each sample collection was compared with pre treatment weed dry weight and expressed in percent. The data were subjected to independent 't' test.

Results and discussion

The study revealed that there was significant difference in work capacity, energy consumption, cost of operation and rate of regeneration of weeds in different weed control methods.

Work capacity

The highest work capacity or the least time required for weeding was observed in mechanical method (weed cutters) which was significantly superior to manual and chemical methods (Table 1). The time taken for weeding by weed cutter was 16 h ha^{-1} and that in chemical and manual methods were 20.71 and 196.66 h ha^{-1} respectively. The manual method of weed control was laborious and time consuming. The working hours for labourers in the experiment station was 8 hrs a day and around 25 days sickle weeding (slashing) was required for completing the weeding operations in an area of one ha. Thus, the time efficiency for weed control by

Table 1. Comparison of work capacity and energy consumption of different weed control methods

Method of weed control	Work capacity (h ha^{-1})	Energy consumption (MJ ha^{-1})
Manual	196.66	133.73
Chemical	20.71	38.03
Mechanical	16.00	358.25
T stat		
Manual Vs. Chemical	17.55**	14.02**
Manual Vs. Mechanical	18.00**	12.00**
Chemical Vs. Mechanical	3.30**	18.35**

** Significant at P< 0.01

weed cutter was 12.5 times more than the manual method.

Energy consumption

The energy consumption indicated that the total energy used in different weed control methods was significantly different (Table 1). The chemical method (herbicide spraying) consumed 38.03 MJ ha^{-1} energy, which was significantly lower than manual and mechanical methods. The highest energy consumption of 358.25 MJ ha^{-1} was registered in mechanical weed control method followed by manual method (133.73 MJ ha^{-1}). The high unit energy of fuel used in weed cutter contributed to the highest energy consumption in the mechanical weed control, compared to other methods (Safa and Tabatabaeefar, 2002).

Weed regeneration

The different weed control methods had significant effect on regeneration of weeds (Table 2). In manual and mechanical weed control methods, the weeds attained 100 per cent of regeneration 75 and 90 days after treatment imposition respectively. In herbicide applied plots, regeneration of weeds initiated only after 60 days of treatment imposition. Weed regeneration was 23.22 and 28.3 per cent respectively, at 75 and 90 days after treatment imposition. The data showed that more rounds of weeding are required in manual and mechanical weed control methods to keep weeds under check compared to chemical method. In manual method, weeds were cut back at 25 cm from the ground level and quick regeneration occurred from this part. In mechanical method, weed cutting was done close to the ground at about 10 cm from ground level and the weed regeneration was slower compared to manual method. Generally, slashing and weed cutting by weed cutters damaged the aerial part of weeds but with less damage to the root system or under ground parts (Senarathne *et al*., 2003). In chemical method, translocation of glyphosate into the plant parts kills the plants and prevents fast regrowth (Jaequeline *et al.*, 1991). In manual and mechanical weed control methods the slashed or removed aerial parts of the plant can serve as mulch on the ground and help to conserve soil moisture and increase soil fertility. Application of glyphosate kills the existing weed population and results in a bare ground compared to the other two methods up to the regeneration of weeds, and this increase the chance of soil erosion.

Table 2. Regeneration (%) of weeds in different weed control methods

Methods of weeding	Days after treatment imposition				
	30	45	60	75	90
Manual	57.60	64.67	77.93	102.55	121.18
Chemical	-	-	-	23.22	28.30
Mechanical	40.70	47.70	60.33	82.38	102.95
T stat					
Manual Vs. Mechanical	15.64**	17.21**	16.91**	10.32**	11.76**
Manual Vs. Chemical				68.77**	62.54**
Chemical Vs. Mechanical				33.85**	60.95**

**Significant at P < 0.01

Economics

The cost of different weed control methods were compared (Fig. 1). The cost of labour was computed on the basis of the wage levels prevailing in Rubber Board's Farms. In mature rubber plantations 25 labourers were required for manual weeding in an area of one hectare and the cost of weeding was Rs. 7300 per ha. For mechanical and chemical methods cost of operation was Rs. 1782

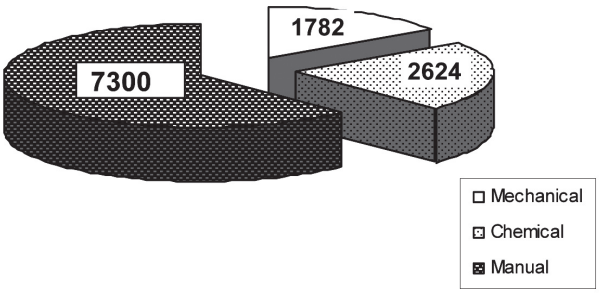

Fig. 1. Cost of different weed control methods (Rs ha^{-1})

and Rs. 2624 per hectare respectively. The cost comparison of different weed control methods showed that the cost of operation per ha was highest in manual method of weed control followed by chemical method and mechanical method. In immature rubber plantations 3-4 rounds of weeding per year is recommended up to the establishment of cover crop and in mature rubber plantations two rounds of weeding is usually sufficient to keep the weeds under check. Since the weed generation in the chemical method is slower, the frequency of weed control needed will be less compared to manual and mechanical methods. However, a rain free period of 4-6 hours after herbicide application is necessary for effective weed control and hence weed control by herbicide application is often difficult during rainy season, particularly in the current scenario of climate uncertainty. Considering the above, cost comparison is made only for one weeding operation. The data showed that the weeding cost can be reduced by 65 and 75 per cent by chemical and mechanical weed control methods respectively, compared to manual method.

Conclusion

The results of the study revealed that there was significant difference in work capacity, energy consumption, cost of operation and rate of regeneration of weeds among different weed control methods. The work capacity was highest and cost of weed control was lowest in mechanical weed control method whereas the energy consumption and rate of regeneration of weeds were lowest in chemical weed control. The cost comparison of different weed control methods showed that around 75 per cent of saving in cost of weeding can be achieved by mechanical method compared to manual method. Considering the long term sustainability, environmental impacts, scarcity of labourers and economics, mechanical weed control by weed cutters is the most suitable weed control method in rubber plantations.

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