

Evaluation and Adoption Scope of Rotary Power Weeder for Weed Management in Vegetable Crops

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Abstract

In this study, a commercial self-propelled rotary power weeder was evaluated in wide space line sown three vegetable crops i.e. tomato (*Solanum lycopersicum*), yard long bean (*Vigna sesquipedalis*) and okra (*Hibiscus esculenta*) crop at research field of Agricultural and Food Engineering Department IIT Kharagpur, West Bengal during 2010-13. The weeder was installed with 4 kW air cooled diesel engine with 3 forward and 2 reverse speed transmission systems. Twelve L-shape weeding blades on three flanges was attached at rearward of the self-propelled unit. Field capacity, field efficiency, weeding efficiency and plant damage was observed during the field evaluation. The observed field efficiency of self-propelled rotary weeder was 86.7, 82.4 and 87.2% and effective field capacity was 0.092, 0.080, 0.096 ha h⁻¹ at a forward speed of 2.3, 2.0 and 2.4 km h⁻¹ in tomato, yard long bean and okra, respectively. Effective working width of operation was 400 mm. The depth of operation was 53, 46 and 50 mm for tomato, yard long bean and okra, respectively. Weeding efficiency in tomato, yard long bean and okra was found as 96, 94 and 97%, respectively with plant damage of 1.6, 2.8 and 1.9%, respectively. Feedback from 35 respondents was conducted for adoption of rotary power weeder in vegetable crop. Analysis shows that more than 96% farmers were willing to the adoption of rotary power weeder through the custom hiring services.

1. Introduction

Vegetables are good source of farm income than other traditional crops. They play an important role in human diet with rich sources of vitamins and other essential nutrients. Vegetable crop establishment is necessary to eliminate the effect of weeds, pests and disease infestation to provide suitable conditions for optimum yield of crops. Weeds are the bounding factors of agricultural production, which compete crop plants with their rapid growth (Tamado and Milberg, 2000). Weed control measures must be put in place to check the growth and propagation of weeds. Chemical and mechanical weed control methods are viable alternatives; however, the environmental impacts of herbicides made chemical methods unsustainable. Weeding operation is viable solution for the removal of unwanted plants in the crop production (Sharma et al., 2014). Wages rate for weeding and intercultural operation in the state of West Bengal is about ₹ 175 Day⁻¹ (Singh et al., 2013). So the cost of weed management was highest in cost of production. It is one of the tedious operations in vegetable production.

The earliest, simplest and most popular weed management method is manual weed control in vegetable production. Now advanced hand tools like khurpi, wheel hoe, hand hoe, etc. are mostly used for weeding and intercultural operations. These weeding methods were expensive, time consuming and labour intensive (Weide et al., 2008). There was an acute labor shortage, which results in increased labor wages and delay in the weeding operation. The introduction of chemical weed control along with manual weeding method has eased these undesirable factors (Lhungdim et al., 2013). However, the emergence of herbicide-resistant weeds has bad impact on environment. In chemical weeding weedicide application was selective, expensive, and hazardous. Increasing the demand for chemical free foods has led to investigate the alternative methods for weed control. Mechanical weed control is very effective and best suitable alternative with reducing drudgery over manual weeding. It removes the weeds ensuring soil aeration and water intake capacity of soil surface.

Mechanical weeding has increased yield of field crop and



vegetables rather than using hand weeding (Senthilkumar, 2003; Alizadeh, 2011). Rotary power weeder works better in respect of average working depth (56.7 mm) which is 16.67% more than bullock drawn blade weeder (Tewari et al., 2014). Plant damage was increased with decrease in moisture content below 11.63% (Goel et al., 2008). There are so many studies conducted on performance of manual, animal and power operated weeders in grain crop. But no study was conducted on performance of self-propelled rotary weeder in vegetable cultivation. Keeping, the above facts in mind the objective of this study was to evaluate the performance and the scope of commercialization of self-propelled rotary weeder in line sown vegetable crops in the state of West Bengal.

2. Materials and Methods

A commercially available self-propelled rotary power weeder was selected for this study at Agricultural and Food Engineering Department, IIT Kharagpur, West Bengal during year 2010 to 2013. The weeder was installed with 4 kW air cooled diesel engine with 3 forward and 2 reverse speed transmission systems. 12 L-shape weeding blades on three flanges was attached at rearward of the self-propelled unit. Handle and the control levers are provided to control the direction and speed of operation. Height of weeder was adjustable according to height of operator between 400-1140 mm from the ground level. Three wide row line sown vegetable crops i.e. tomato, yard long bean and okra were used in this study at research farm. A 0.5 ha plot was selected for the field trials of each crop. The soil type was sandy clay loam. Row to row spacing of tomato, yard long bean and okra planting was 650, 700 and 600 mm, respectively. Trials were carried out after 22 days of planting in tomato and after 24 days of sowing in okra and yard long bean. The field was infested mostly with grassy weeds such as *Echinochloa crusgalli*, *Trifolium repens* and *Cyperus rotundus*. At that stage, the crop height and the density of weeds were measured with a standard quadrat. Soil moisture, cone index and bulk density were also measured and recorded.

Bulk density of soil was measured by core cutter method and cone index was measured by a digital cone penetrometer. Three soil samples were collected from each test plots with the help of soil sampling auger for moisture measurement. Initial weight (W1) of each sample was taken on digital balance and dried it at 105°C for 8 hours. Dried sample were collected from oven and final weight (W2) was taken. Moisture content (MC) on dry basis has been calculated by equation (1) (Chen, 2003). In order to determine the weeding efficiency, 10 randomly patches of 1×1 m size was taken and the number of weeds were counted before and after weeding operation. The weeding efficiency

$$MC (db) = \frac{W1-W2}{W2} \times 100 \quad (1)$$

(Remesan et al., 2007) was calculated by the equation (2).

Where, WE is the weeding efficiency of the weeder (%), N1

$$WE = \frac{N1-N2}{N2} \times 100 \quad (2)$$

and N2 are the number of weeds before and after weeding operation, respectively.

To determine the plant damage, the numbers of damaged plants were counted randomly selecting 1 m length of crop row at 10 locations of each plot. Then, plants damage % as a quality of work done (Tewari et al., 1993) was obtained by the equation (3).

Where, DP is the plants damage (%), Q1 and Q2 are the

$$DP = \frac{Q1}{Q2} \times 100 \quad (3)$$

damaged plants and total number of plants per unit length, respectively.

Effective field capacity (C_e), field efficiency (F_e) and work capacity (W_c) were calculated by the following equations (Hunt, 1995)

$$C_e = \frac{S \times W \times E}{10} \times 100 \quad F_e = \frac{T_e}{T_t} \times 100 \quad W_c = \frac{1}{C_e} \quad (4) \quad (5) \quad (6)$$

Where, C_e is the effective field capacity ($ha\ h^{-1}$), S is the travel speed of the weeder ($km\ h^{-1}$), W is the width of operation (m), F_e is the field efficiency of the weeder (%), T_t and T_e are the total and useful working time (h), respectively and W_c is the working capacity ($h\ ha^{-1}$).

The potential of equipment could be harnessed effectively by demonstration to the target group. For this a questionnaire was framed for getting feedback from farm workers and vegetable grower (respondents) regarding adoption of self-propelled rotary weeder over conventional methods. The response of 35 respondents on operation of this equipment and reasons for adoption and purchasing are given in Table 1. The cost of operation per hour for operating self-propelled rotary weeder was calculated by straight line depreciation method (Singh, 2007).

3. Results and Discussion

3.1. Work capacity

Soil moisture content of the test field was found as 15.42 % (db). Bulk density of the field after operation was found as 1.32 $g\ cc^{-1}$ and value of cone index before and after the weeding operation was given in (Table 1). Effective width of weeder was 400 mm and average depth of operation in tomato, yard long bean and okra was 53, 46, and 50 mm, respectively (Table 1). Weeding depth in yard long bean was less due to hardness

of soil. The effective field capacity of the power weeder was 0.092, 0.08, and 0.096 ha h⁻¹ for tomato, yard long bean and okra, respectively (Table 1). The effective field capacity and field efficiency in yard long bean was quite less than tomato and okra due to tilted crop and high weed infestation. The field efficiency of weeder was 86.7, 82.4, and 87.2% in tomato, yard long bean and okra field, respectively. Minimum time required for weeding in line sown crop was 10.4 h ha⁻¹ in okra. The average fuel consumption was relatively high (0.43 and

5.4 l ha⁻¹) in yard long bean and almost same consumption was recorded in tomato and okra crop weeding. The weeder have small turning radius which was 0.79 m, helpful in weeding in vegetable fields. Intra row weeding operation by self-propelled rotary weeder in tomato and yard long bean is shown in (Figure 1).

3.2. Weeding quality and cost of operation

Field performance of self-propelled rotary weeder in different vegetable crops are shown in (Figure 2). Damages like cut, uproot and graze etc., to the vegetable plants during operation with weeder were also observed. No stem damage was found in whole weeding operation due to wide inter row spacing of crop. Plant damage was higher (2.8%) in yard long bean crop due to the more branches and tilted plants, whereas, in tomato it was 1.6% crop. During field operation it observed that clean weeding was obstructed due to large and fibers weed entangled in both end of rotary shaft. There was no clogging of weeds observed in middle portion. No mechanical damage was observed in the weeder during field operation. The cost of operation of weeder in different crop was calculated by considering fixed cost and variable cost. The lowest cost of operation ₹ 589 ha⁻¹ was observed for okra. This may be due to higher field capacity and low cost of the developed weeder.

3.3. Scope for commercialization

The target group showed their keen interest to use rotary power weeder over the traditional method (Table 2). indicated the suitability in study area. The product was designed and developed, using Indian farm workers' anthropometric dimensions, which helped the subject to operate for longer duration. It was observed that the subject could operate the

Table 1: Results of the performance evaluation of self-propelled rotary weeder in different vegetable crops

Parameters	Unit	Performance		
		Tomato	Yard long bean	Okra
Soil type		Sandy clay loam	Sandy clay loam	Sandy clay loam
Cone index (before testing)	k pa	270	285	260
Cone index (after testing)	k pa	90	110	90
Bulk density (after testing)	g cm ⁻³	1.32	1.32	1.32
Theoretical width of operation	mm	460	460	460
Effective Width of operation	mm	400	400	400
Depth of weeding	mm	53	46	50
Row to row spacing of crop	mm	650	700	600
Forward speed	km h ⁻¹	2.3	2.0	2.4
Theoretical field capacity	ha h ⁻¹	0.106	0.097	0.11
Effective field capacity	ha h ⁻¹	0.092	0.08	0.096
Field efficiency	%	86.7	82.4	87.2
Work capacity	h ha ⁻¹	10.9	12.5	10.4
Weeding efficiency	%	96	94	97
Plant damage	%	1.6	2.8	1.9
Fuel consumption	l h ⁻¹	0.40	0.43	0.40
Fuel consumption	l ha ⁻¹	4.36	5.4	4.16
Labour requirement	man ^h ha ⁻¹	12	14	12
Cost of operation	₹ ha ⁻¹	594	608	589
Cost of operation	₹ h ⁻¹	45	45	45

Table 2: Feedback from respondents on adoption of power weeder in vegetable crop

Feedback of respondents	Average response of subjects (N = 35), %	
Operation of equipment	Ease in operation	95
	Safety in operation	93
	Fatigue in operation	11
Reasons for adoption	Higher output	100
	Negligible plant damages	94
	Cost effective	95
	Ease in movement	89
	Less chances of weed trapping	95
Purchasing the equipment	Suitable for other than weeding	100
	Higher cost	86
	Custom hiring	96





Figure 1: Self-propelled rotary weeder operation in tomato and yard long bean field

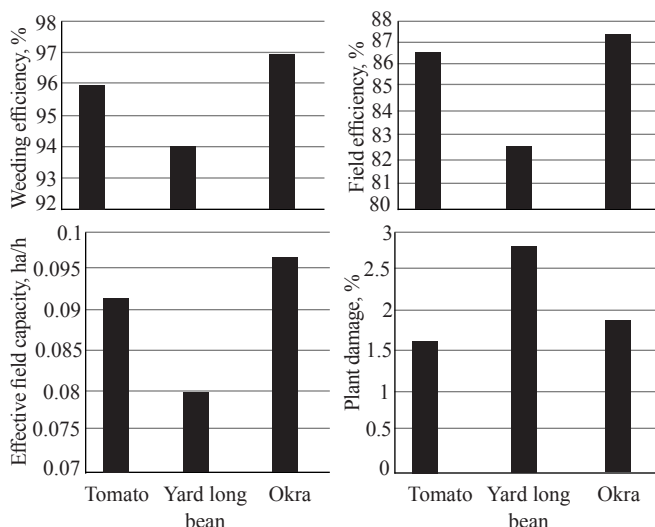


Figure 2: Field performance of self-propelled rotary weeder in different vegetable crops

self-propelled weeder easily (95%) with less safety in operation (93%). Higher output, and ease handling of equipment are the main reasons for adoptions in vegetable cultivation. The machine is simple in construction, repairable locally and eases in field operation. Custom hiring would be the right solution for the target group (96%) in West Bengal. The weeder price was ₹ 88000.00 (1470 US\$) and this cost may be reduced up to 12% after its commercialization.

4. Conclusion

Rotary power weeder works satisfactorily. Weeding efficiency was more than 94% in all crops. The effective field capacity of weeder was highest in okra (0.096 ha h^{-1}) than tomato and yard long bean. Turning radius of power weeder was small (about 0.79 m) which was helpful in taking short turn without damaging the plants. At some places adoption of mechanical inter-row weeder was not supported by the existing cropping systems.

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