J. Indian Soc. Coastal Agric. Res. 37(1): 51-55 (2019)

Development and Performance Evaluation of a Power Operated Paddy Weeder for Lowland Paddy in Konkan Region

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Received: 30.08.2018 Accepted: 27.05.2019

Paddy is the major crop cultivated under wet land condition in the Konkan region of Maharashtra. Weed control is widely achieved by means of hand weeding which is labour-intensive, time consuming and costly. To reduce the drudgery involved in paddy weeding and enhance field capacity, the work was undertaken to develop a portable power weeder for paddy. The developed paddy weeder consisted of engine, gear box, propeller shaft, rotor with blade, main frame and float. Two types of blade one L shape and the other hexagonal serrated blade were designed and tested. The components viz., engine, gear box, rotor shaft, mudguard, float, handle, etc. were assembled and the final prototype developed, was tested for its performance in field. The rotor with serrated blade resulted in 9.41% higher weeding efficiency than "L" shape blade at 40 DAT (Days after transplanting). Rotor with "L" shape blade resulted in 1.02% less plant damage as compared to serrated blade at 20 DAT. Higher (30.4%) field capacity was found with L shape blade (0.0266 ha h^{-1}) as compared to serrated blade (0.0204 ha h^{-1}) at 40 DAT. Minimum fuel consumption (0.576 L h^{-1}) was found with ''L" shape rotor blade at 40 DAT, however, higher fuel consumption (0.646 L h^{-1}) was observed using serrated blade at 40 DAT. The weeder with serrated blade had higher weeding efficiency.

(***Key words:*** *Field capacity, Paddy, Performance evaluation, Power operated weeder*)

India has largest area under rice (43.50 million ha) with the production of 104.41 million tonnes. It ranks second only to China with the average productivity about 2400 kg ha^{-1} during the year 2015-2016 (Anonymous, 2018a). Maharashtra has 1.47 million ha land under rice cultivation with production about 3.42 million tonnes and productivity 2327 kg ha^{-1} during the year 2016-2017 (Anonymous, 2018b).

Weeds are unwanted and undesirable plants that interfere with utilization of land and water resources and thus adversely affect crop production and human welfare. Weeds also may directly reduce profits by hindering harvest operations and producing chemicals that are harmful to crop plants (Biswas *et al*., 2000). Weed control is one of the most difficult tasks in agriculture that accounts for a considerable share of the cost involved in agriculture production. More than 33% cost incurred in cultivation is diverted to weeding operations thereby reducing the profit share of farmers. Reduction in yield due to weed alone was estimated to be 16 to 42% depending on crop and location which involves one third of the cost of cultivation (Rangasamy *et al*., 1993). Delay and negligence in weeding operation affect the crop yield and the loss in crop yields due to weeds in upland crops varying from 40 to 60% and in many cases cause complete crop failure (Singh, 1988). Weeding either by hand tools or mechanical weeders are effective in both dry and wet land (Gite and Yadav, 1985; Gite and Yadav, 1990; Nag and Dutt, 1979).The hand weeding method using labours is widely adopted at present for paddy. It is costly and labour-intensive. Manually operated cono weeders are being used in some of the pockets of Konkan but its capacity is less upto 0.12-0.15 ha day^{-1}. In order to make weeding operation comfortable with higher field capacity, efforts were made to develop power operated weeder suitable for Konkan region.

MATERIALS AND METHODS

To reduce the drudgery involved, the efforts were made to develop with two type blades *viz*. L shape and Hexagonal serrated. Normally recommended row to row spacing and plant to plant spacing for paddy crop is

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25×15 cm in Konkan region. To make it more easy for handling the power weeder was made light in weight. To increase field capacity and reduce drudgery 1.7 HP petrol engine was selected as a prime mover for the power weeder.

The developed paddy weeder consists of engine, gear box, propeller shaft, rotor with blade, main frame and float. A petrol engine of 1.7 HP @ 6500 rpm (make- Premier Hawk, 2 Stroke) was selected as prime mover for the development of weeder. The reduction gear box with gear ratio of 32.5:1 was used to reduce the speed to 200 rpm. The same speed was given to rotor of the machine. The bottom of the weeder was provided with the float. Total working width of the weeder was 300 mm having rotor shaft length 500 mm. To avoid throwing of mud and stones towards operator a mud flap is provided covering the upper and rear side of the blades of the rotary cutting units.

A petrol engine of 1.7 HP was incorporated as prime mover for the developed weeder. The speed of cutting unit (rotary blade) was kept as 200 rpm. The speed ratio of engine to cutting blade was 32.5:1. Two types of blade were designed and developed *viz*., L shape and hexagonal serrated blade. The rotor blade consisted of four "L" shaped blades mounted orthogonally opposite direction on a rotary flange which is attached to the rotator shaft. The hexagonal rotor with serrated blade was fabricated from 2 mm thick MS sheet of 150 mm length and 45 mm width. The rotor blade consisted of six blades connected on a hexagonal rotor. The components *viz*., engine, gear box, rotor shaft, mudguard, float, handle etc. were assembled and final prototype was developed. Performance of developed weeder was evaluated in field.

L shape blades are the most commonly used for the fields with crop residue for removing weeds (Bernacki *et al*., 1972; Khodabakhshi *et al*., 2013). Therefore, L shape blade geometry was selected for the present study. Four L shaped blades connected in orthogonally opposite direction on a rotary flange which is attached to the rotator shaft by means of sleeved hub and nut bolt (Fig. 1). Considering the usefulness of serrated blade, in this study the serrated blade geometry was also selected for rotor design. There were two flanges (one each side) on rotor shaft and on each rotor four M.S. blades were fitted. The different views and dimension of serrated blade with hexagonal rotor is shown in Fig. 2.

The float of the developed weeder serves as a base which helps in easy movement of the implement over puddled field. The developed paddy weeder is shown in Fig. 3.

RESULTS AND DISCUSSIONS

The developed weeder was tested on three subplots. Three subplots were selected randomly. The performance of the power weeder with rotor of two blades *viz*., rotor with L shape blade and serrated blade was tested at three growth stages of paddy crop *i.e*., 20 days after transplanting (DAT), 30 DAT and 40 DAT.

Performance of developed weeder with L shape blade

Using L shape rotor blade maximum weeding efficiency (79.85%) was found at 40 DAT followed by 20 DAT (77.25%) and 30 DAT (77.11%). The plant damage was found to be 0.97% at 20 DAT, 1.61% at 30 DAT and 1.84% at 40 DAT (Table 1). Minimum plant damage was found at 0.97% at 20 DAT. Actual field capacities were found to be 0.024, 0.0264 and 0.0266 ha h^{-1} 20, 30 and 40 DAT, respectively (Table 2). The highest field efficiency was found to be at 84.82% at 40 DAT. The fuel consumption of the power weeder with L shape blade was found to be 0.594 L h^{-1}, 0.581 L h^{-1} and 0.576 L h^{-1} at 20 DAT, 30 DAT and 40 DAT, respectively (Table 2).

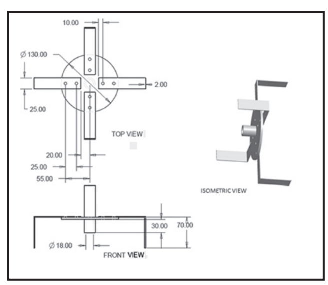

Fig. 1. *Details of L shape blade*

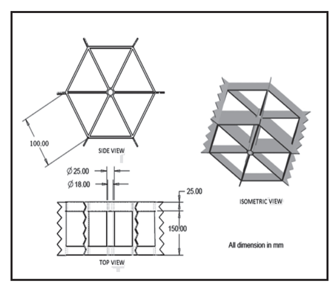

Fig. 2. *Details of hexagonal rotor with serrated blade*


Fig. 3. *A view of developed power operated paddy weeder*

Table 1. *Weeding efficiency and plant damage observed for developed weeder with L shape blade*

Sr. No.	Particular	Observed weed count									Average
		Plot No 1			Plot No 2			Plot No 3			
		L_1	L_2	L_3	L_1	L_2	L_3	L_1	L_2	L_3	
	Weeding efficiency										
1	Weeding efficiency %, 20 DAT	77.55	78.86	75.68	79.67	76.54	75.70	73.91	85.32	78.03	77.25
2	Weeding efficiency %, 30 DAT	73.89	79.38	74.42	76.32	76.92	75.94	78.70	79.36	79.10	77.11
3	Weeding efficiency %, 40 DAT	79.17	78.08	79.14	78.89	80.87	76.14	82.69	79.17	81.03	79.85
	Plant damage										
1	No. of damaged plant, 20 DAT	2	3	2	1	1	1	1	2	3	
2	Plant damage, %	1.10	1.79	1.13	0.49	0.52	0.51	0.54	1.02	1.70	0.97
3	No. of damaged plant, 30 DAT	2	1	4	5	2	6	5	5	3	
4	Plant damage, %	0.90	0.48	1.83	2.02	0.84	2.67	2.53	2.05	1.20	1.61
5	No. of damaged plant, 40 DAT	2	3	4	9	3	5	3	3	5	
6	Plant damage, %	1.00	1.53	1.83	3.61	1.14	2.26	1.38	1.55	2.2	1.84

Note: L_1 to L_3 - locations selected randomly within the plot

Table 2. *Field capacity, field efficiency and fuel consumption of the power weeder using L shape blade*

Sr. No.	Particular	Location			Average
		Plot No 1	Plot No 2	Plot No 3	
	At 20 DAT				
1	Field capacity, ha h^{-1}	0.0248	0.0232	0.0242	0.024
2	Field efficiency, %	79.29	77.15	78.67	78.37
3	Fuel consumption, L h^{-1}	0.609	0.60	0.572	0.594
	At 30 DAT				
1	Field capacity, ha h^{-1}	0.0264	0.0277	0.0252	0.0264
2	Field efficiency, %	83.33	85.32	80.55	83.07
3	Fuel consumption, L h^{-1}	0.58	0.59	0.573	0.58
	At 40 DAT				
1	Field capacity, ha h^{-1}	0.0277	0.0273	0.0247	0.0266
2	Field efficiency, %	86.59	86.53	81.35	84.82
3	Fuel consumption, L h^{-1}	0.577	0.579	0.571	0.576

Table 3. *Weeding efficiency and plant damage observed for developed weeder with serrated blade*

Sr. No.	Particular	Observed weed count									Average
		Plot No 1			Plot No 2			Plot No 3			
		L_1	L_2	L_3	L_1	L_2	L_3	L_1	L_2	L_3	
	Weeding efficiency										
1	Weeding efficiency %, 20 DAT	84.18	81.66	80.61	80.68	82.73	79.31	81.60	83.41	84.78	82.11
2	Weeding efficiency %, 30 DAT	87.55	85.30	82.05	83.63	82.11	87.50	85.54	84.12	84.86	84.74
3	Weeding efficiency %, 40 DAT	88.39	87.61	86.36	84.62	87.85	89.42	88.10	87.63	86.27	87.37
	Plant damage										
1	No. of damaged plant, 20 DAT	3	1	2	5	0	2	1	1	2	
2	Plant damage, %	1.34	0.46	0.96	2.53	0	1.18	0.62	0.61	1.11	0.98
3	No. of damaged plant, 30 DAT	4	5	4	6	3	6	3	4	4	
4	Plant damage, %	1.56	2.04	1.39	2.15	1.20	2.19	1.20	1.58	1.44	1.67
5	No. of damaged plant, 40 DAT	7	7	4	11	9	11	8	7	6	
6	Plant damage, %	2.17	2.20	1.17	3.20	2.76	3.28	2.28	2.13	1.75	2.40

Note: $L_1$to L_3 - are locations selected randomly within the plot

Table 4. *Field capacity, field efficiency and fuel consumption of the power weeder using serrated blade*

Sr. No.	Particular	Location			Average
		Plot No 1	Plot No 2	Plot No 3	
	At 20 DAT				
1	Field capacity, ha h^{-1}	0.0193	0.0196	0.018	0.0189
2	Field efficiency, %	76.78	75.94	74.53	75.72
3	Fuel consumption, L h^{-1}	0.673	0.668	0.6545	0.665
	At 30 DAT				
1	Field capacity, ha h^{-1}	0.0203	0.0193	0.0196	0.0197
2	Field efficiency, %	80.62	78.10	81.59	81.06
3	Fuel consumption, L h^{-1}	0.661	0.651	0.652	0.655
	At 40 DAT				
1	Field capacity, ha h^{-1}	0.0203	0.0193	0.0196	0.0197
2	Field efficiency, %	80.62	78.10	81.59	81.06
3	Fuel consumption, L h^{-1}	0.661	0.651	0.652	0.655

Performance of developed weeder with serrated blade

The weeding efficiency was calculated for each operation of weeder after 20, 30 and 40 DAT. The highest weeding efficiency was observed as 87.37% at 40 DAT, and minimum weeding efficiency was found as 82.11% at 40 DAT. The weeding efficiency of the weeder using serrated blade was not much affected by time of weeding and growth of rice crop. The minimum plant damage was found at 0.98% at 20 DAT (Table 3).

Maximum field capacity (0.0266 ha h^{-1}) was found at 40 DAT followed by 20 DAT (0.01897 ha h^{-1}) and 30 DAT (0.01973 ha h^{-1}). The highest field efficiency was found to be 81.11% at 40 DAT. The fuel consumption of weeder using hexagonal serrated rotor was found to be 0.665 L h^{-1}, 0.655 L h^{-1} and 0.654 L h^{-1} at 20 DAT, 30 DAT and 40 DAT, respectively (Table 4).

Weeding efficiency using serrated blade rotor was 9.41% higher as compared to L shape blade at 40 days after transplanting. L shape blade resulted in to 1.02% less plant damage than serrated blade at 20 days after transplanting. Field capacity with L shape blade was 35% higher (0.0266 ha h^{-1}) as compared to serrated blade (0.0197 ha h^{-1}) at 40 days after transplanting. The fuel consumption with L shape blade at 40 days after transplanting was 0.576 L h^{-1} and using this blade saved 12.06% saving over serrated blade. Though the weeder with serrated blade resulted slight higher fuel consumption, less field capacity but it had 9.41% higher weeding efficiency. The plant damage while operating power weeder in field using both the rotor blades was almost same. In terms of weeding performance the weeder using serrated blades was found to be better over L shape blade.

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