

Performance evaluation of weeders in rice cultivation

P C Mohapatra*, S P Patel, M Din and P Mishra

Central Rice Research Institute, Cuttack - 753 004 (Odisha)

Email : purnacmohapatra@hotmail.com

ABSTRACT

Experiments were conducted during dry season of 2010 to 2012 to study the field efficiency of weeders, developed at Central Rice Research Institute, Cuttack. The weeders, namely bullock drawn, self propelled, star-cono and finger weeders, reduced the cost of weeding by 68%, 61%, 60% and 34%, respectively, compared to manual weeding. Under wet soil condition performance of the star-cono weeder was the best as per highest ear bearing tillers (196 m^{-2}), grain and straw yields (4.08 and 7.34 t ha^{-1} respectively), water productivity ($\text{₹ }1242\text{ m}^{-3}$) and total weed destruction. But in dry soil condition, performance of self propelled weeder was better than other weeders including manual-weeding in terms of labour requirement, weed destruction and profitability. Weeding by use of bullock drawn weeder was the most economic ($\text{₹ }1815\text{ ha}^{-1}$) but net return from rice cultivation was highest in case of star-cono weeder ($\text{₹ }8472\text{ ha}^{-1}$) against $\text{₹ }3,994\text{ ha}^{-1}$ in case of manual weeding and the net loss of $\text{₹ }3,766\text{ ha}^{-1}$ in case of un-weeded plots.

Key words: rice weeder, grain yield, water productivity, net return

In irrigated ecosystem rice productivity has reached a plateau though a vast scope exists to improve it in rainfed ecosystem. Coupled with cloudy weather and vagaries of nature, productivity of rice in wet season is not up to the potential level. For this reason, dry and boro rice cultivations is gaining popularity especially in eastern parts of India. But due to scarcity of irrigation water in these seasons, maintaining standing water in crop fields is difficult. Alternate wetting and drying of the rice fields in rainfed uplands in wet season, aerobic rice and SRI (system of rice intensification) in dry and boro seasons create a favorable environment for weed growth. Keeping rice fields free of weeds in this situation is cost intensive. This results in marginal profit from rice cultivation.

Field studies have established that mechanical weeding in rice cultivation ensures timely operations, reduces labour requirement and enhances grain productivity and profitability. Ampong-Nyarko and De Datta (1990) reported that IRRI conventional push-pull single row rotary weeders required 80-90 labour-hours ha^{-1} whereas, single row and two row cono

weeders with rotor were 2 and 3-4 times faster than the conventional weeders, respectively. They advocated that mechanical weeding should be supplemented by hand-pulling of the weeds, close to the rice plants. To achieve best results in transplanted rice, a weeder should run in two directions, at right angles to each other. Thiyagarajan (2006) quoted various authors on increase of grain and biomass yields (9% to 24%) due to use of mechanical weeders compared to hand weeding. This increase was attributed to continued stirring of soil, resulting in prolonged active leaves and higher number of productive tillers. Sarma *et al.* (2007) reported that SRI transplanting and weeding require 50% more man-days than traditional method. Weeding by cono weeder lessened fatigue of labourers because the weeder allows standing position of the operator during weeding. A study at Acharya NG Ranga University, Andhra Pradesh, India, showed that the use of cono weeders increased efficiency of women labourers by 76% compared to traditional hand weeding. Nkakini *et al.* (2010) developed a manually operated engine driven rotor weeder with an effective field capacity of 0.34 ha hr^{-1} which was 6 times more than

that of manual weeding. The weeder had weeding efficiency of 71% in removing shallow rooted weeds. Hossen *et al.* (2012) developed a single row manual weeder suitable for both upland and lowland situations with field capacity of 6.6 decimal hr⁻¹ and 8.3 decimal hr⁻¹, respectively. The machine could be used for weeding of rice, pulses, groundnut in upland situation. Mohapatra *et al.* (2012) from a study on mechanical planting and weeding of modified SRI, reported that the mechanization enhanced productivity of SRI by 12% and profitability by 360% (from ₹ 2,650 to ₹ 12,192 ha⁻¹) due to higher plant density and lower labour cost. Various innovative designs of manual and mechanical rice weeders (1-4 rows) were reported by WASSAN (2006). These include Raichur, Kollur, Mandava, Tharimela, Tamilnadu, Jharkhand, Tefy Saina, Japanese, English, Nepalese, Srilankan and Cambodian weeders.

Keeping the above facts in view, a study was undertaken at Central Rice Research Institute, Cuttack, India in dry season of 2010-12 to study the field efficiency of weeders developed at the institute, namely finger weeder (Table 1), star-cono weeder, bullock drawn weeder and self propelled weeder in relation to grain and straw yields, water productivity, cost of cultivation and net returns from rice farming.

MATERIALS AND METHODS

The experiment was conducted with rice variety of Naveen. Experimental plots were subjected to alternate wetting and drying by applying irrigation water on appearance of hairline cracks. Same nutrient level was maintained in all the treatments with application of 5.0 t farm yard manure and 80:40:40 kg NPK per hectare. The experimental plots were arranged in randomized block design with 3 replications.

Operational efficiency of CRRRI weeders was studied by comparing their field performance, cost of operation and net returns from sale of straw and paddy. Time taken by the weeders for weeding of the treatment-plots of 154m² size was recorded to determine field capacity of the implements. This was compared with manual weeding and no-weeding. Plant height from 10 hills and number of ear bearing tillers from a square meter area of each treatment-plot were recorded before harvest. Sun dried grain and straw yields from the whole plots were recorded. Local hiring charge, including operator wage of self propelled engines were used to calculate cost of power weeding. Similarly local rates for labour and pair of bullocks were used for calculation of cost of manual and bullock drawn weeding.

Water productivity was determined as the ratio of net return from sale of straw and paddy and evapotranspiration (ET). ET was computed from the water balance in crop field mentioned below :

$$ET = R - R_o - SP \pm S_r + W_s \quad \dots \quad (1)$$

Where, R= rainfall,

R_o= runoff,

SP= seepage and percolation,

S_r= soil profile contribution or retention, and

W_s= water applied from sources other than rainfall (irrigation).

During period of crop growth period of the 3 years (20th Jan. to 25th May), average rainfall received was 138mm. There was no runoff from the plots. Average seepage and percolation, recorded from drum-culture was 4.85 mm day⁻¹ (for 124 days: 601mm). Net soil profile contribution, determined before sowing of the crop and after harvest, was negligible. Average irrigation water applied (W_s) was 1145mm.

Table 1. Specifications of the CRRRI weeders

Weeder	Length (cm)	Width (cm)	Height (cm)	Weight (kg)	Width of coverage (cm)
Finger weeder	174	7.5	8	1.4	7.5
Star-cono weeder	171	48	86	7.2	12
Bullock drawn weeder	270	147	90	40	140
Self propelled weeder	172	58	110	90	50

Table 2. Effect of weeding methods on grain and straw yields, water productivity and net returns (cv: Naveen)

Method of weeding	Area covered (ha hr ⁻¹)	Cost of one weeding (₹ ha ⁻¹)	Cost of cultivation (₹ ha ⁻¹)	Plant height (cm)	Straw yield (t ha ⁻¹)	Ear bearing tillers m ⁻²	Grain yield (t ha ⁻¹)	Water productivity (₹ m ⁻³)	Net returns (₹. ha ⁻¹)
Finger weeder	0.0206	3750	31,540	90.8	6.87	178	3.87	721	4916
Star-cono weeder	0.035	2250	30,040	92.8	7.34	196	4.08	1242	8472
Manual weeding	0.0135	5688	33,478	91.5	7.24	192	3.96	586	3994
Bullock drawn weeder	0.084	1815	29,605	90.6	6.42	170	3.68	729	4971
Self propelled weeder	0.075	2220	30,010	90.7	7.05	186	3.78	861	5870
No weeding	-	-	22,590	90.1	4.53	132	1.9	-552	-3766
CD (5%)	-	434.48	3815.01	8.73	0.733	8.91	0.46	42.873	364.16

¹Sale rate of paddy= ₹ 800 q⁻¹ Sale rate of straw = ₹ 80 q⁻¹

Using Eq.1, ET= 138-0-601+0+1145=682mm. Thus 682mm was adopted as ET of Naveen.

RESULTS AND DISCUSSION

In alternate wetting and drying condition, 3 weeding operations were required to keep the plots weed free. In dry land situation finger, bullock drawn and self propelled weeders could be used. Weed destruction was better in case of self propelled weeder than bullock drawn and finger weeders (74%, 55% and 50%, respectively in 2 passes). In wet land situation only cono weeder and finger weeder could be used. Of these two, weed destruction was better in case of cono weeder than finger weeder. As seen from this table, weeding by bullock drawn weeder in dry land situation was most economic (one weeding: ₹ 1815 ha⁻¹). Highest ear bearing tillers (196 m⁻²), straw and grain yields (7.34 t ha⁻¹ and 4.08 t ha⁻¹, respectively) and water productivity (₹ 1,242 m⁻³) were obtained from plots of star-cono weeder. Cost of operation by star-cono weeder was slightly higher than the self propelled weeder (1.3%). Advantages with the star-cono weeder may be attributed to better churning of soil and higher weed damage resulting in new root and tiller development. Variation in plant height was not significant among the experimental plots (average: 91.1cm). Average grain yield (3.85 t ha⁻¹) in mechanically weeded plots were double to un-weeded plots. Although grain yield of mechanically weeded plots were similar to manually weeded plots, the average cost of weeding was 127% less than manually weeded plots. Highest net returns from rice cultivation was obtained in case of weeding by star-cono weeder (₹

8472 ha⁻¹) followed by self propelled weeder (₹ 5870 ha⁻¹). Un-weeded plots suffered from a net loss of ₹ 3766 ha⁻¹ due to low grain yield (1.9 t ha⁻¹). This finding is in conformity with the findings of Parida (2003), Tajuddin (2009) and Mohapatra *et al.* (2012). Average straw yield from weeded plots (6.98 t ha⁻¹) was higher by 54% than the un-weeded plots.

The study shows that self propelled weeder is a better substitute to hand weeding and weeding by finger weeders from weeding cost point of view in dry land situation and performance of star-cono weeder was best from yield and profit point of view in wet land situation.

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