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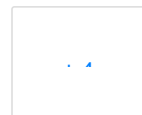
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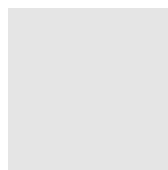


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...s conducted at ICAR Research Complex for Eastern Region, Patna (25°35' N latitude and 85°04' E longitude) to study the performance of weeders i.e. cono and Mandava weeder in SRI under the irrigated weeding efficiency was recorded with mandava weeder as compared to cono-weeder. Mandava weeder consumed ... a. Therefore, mandava weeder may be promoted at farmer's fields in wider scale as it reduces energy use of small community of the Indo-Gangetic Plains of the Eastern India.

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## Comparative performance of manual weeders under system of rice intensification in Indo-Gangetic plains

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**Key words:** SRI, weeder, field capacity, weeding efficiency

Rice (*Oryza sativa* L.) is grown under diverse conditions ranging from irrigated to rainfed upland, deep and deep water. Traditional crop establishment, i.e. puddling and transplanting, requires large amount of water, energy and labour, which are becoming scarce and expensive (Mishra and Singh 2012). Weeds are considered to be one of the major biotic constraints in achieving the higher productivity as they cause a reduction of 10-15% grain yield in rice field (Kumar et al. 2016). System of Rice Intensification (SRI) is a modern and innovative method of rice cultivation for reduced use of water and labour and to increase the crop productivity. But this system is much infested with weeds because growing under the limited water regime. *Echinochloa* spp., *Cynodon dactylon*, *Imperata quadrifida* and *Cyperus* spp. are the major weeds associated with SRI. Herbicides were proved effective but the continuous and indiscriminate use of herbicides for a longer period may result in buildup of resistant biotic weeds and development of herbicide resistance. Adoption of rotary or cono-weeder use in SRI plays a significant role in improving the growth, yield and economics of rice. Weed management with mechanical tools not only uproot the weeds between the rows but also ensuring the better soil aeration. Different type of weeders are available for weeding in SRI, these designs are location specific and developed to meet the requirement of soil type, crop rotation, cropping pattern and availability of the local resources (Goel et al. 2008). Hence, performance of different types of manual weeders was evaluated in SRI in the middle Indo-Gangetic plains.

The field experiment was conducted at ICAR Research Complex for Eastern Region, Patna (25°35' N latitude and 85° 04' E longitude) during the Kharif

season. The experimental site was sub-tropical in nature exhibiting high humidity and medium rainfall. The rice cv. '1509' (120 days duration) was used as test material. The monthly mean maximum and minimum temperature during the crop growing period ranged from 29.2 - 35.4°C and 12.2 - 23.2°C, respectively. The rice seedlings were transplanted at 25×25 cm apart. The specification of the experimental weeder is mentioned in **Table 1**.

**Table 1. Specification of Cono and Mandava weeder**

| Cono weeder                   | Mandava weeder                |
|-------------------------------|-------------------------------|
| Length : 2040 mm              | Length: 1500 mm               |
| Nominal width: 194 mm         | Width (handle): 460 mm        |
| Working width: 125 mm         | Nominal width: 150 mm         |
| Height: 1120 mm               | Working width: 120 mm         |
| Width (handle): 500 mm        | Height: 1000 mm               |
| Type of handle: T-Type        | Type of handle: T-Type        |
| Number of rotors: 02          | Number of rotors: 01          |
| Weight: 6.1 kg                | Weight: 5.1 kg                |
| Unit Cost: ` 1200/- (approx.) | Unit Cost: ` 1000/- (approx.) |

Different test parameters were evaluated with formulae given as below:

Theoretical field capacity Theoretical field capacity was calculated with standard formula as suggested by Mehta et al. (2005).

$$\text{Theoretical field capacity} = \frac{\text{Working width} \times \text{Speed}}{10} \dots\dots\dots$$

Where, working width in m and speed in km/h

Effective field capacity: Effective field capacity is the average output of the weeder per hour and calculated from total area weeded in ha and the total working time (Mehta et al. 2005).

$$\text{Effective field capacity} = \frac{\text{Area covered by weeder}}{\text{Total time taken} \times 10000} \dots\dots\dots$$

Where, Area covered in m<sup>2</sup> and total time in hr

Field efficiency: It is the ratio of the effective

to study the performance of weeders i.e. cono-weeder and Mandava weeder under the irrigated ecosystem. The experimental plot was clay loam (sand: 39.64%, silt: 39.64% and clay: 37%). The climate of

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capacity to theoretical field capacity and expressed in percent (%) and it was calculated by using formula as suggested by Mehta et al. (2005).

$$\text{Field efficiency (\%)} = \frac{\text{Effective field capacity}}{\text{Theoretical field capacity}} \times 100 \dots\dots$$

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$$\text{Field capacity} = \frac{W \times S}{10} \times \frac{E}{10} \dots\dots\dots(4)$$

here, W= theoretical width of cut in m, S = forward travel in km/h, E= field efficiency (%)

Field efficiency: Square loop (0.25 m<sup>2</sup>) was randomly thrown to field and number of weeds remaining in loop was counted before and after weeding (Rangasamy et al.1993). Three sets of observations were taken and weeding efficiency was recorded as below.

$$\text{Weeding efficiency (\%)} = \frac{W_1 - W_2}{W_1} \times 100 \dots\dots\dots(5)$$

here, W<sub>1</sub>= number of weeds before weeding, W<sub>2</sub>= number of weeds after weeding

Plant damage: It was calculated by counting the number of injured plants and total number of plants in plot and expressed in per cent (%) (Biswas et al. 2004).

$$P_d = \frac{A}{B} \times 100 \dots\dots\dots(6)$$

here, Pd = Plant damage (%), A=Injured plant number, B = Total no. of plant in sample plot

Human energy co-efficient 1.96 MJ was recorded as suggested by De et al. (2001)

Force measurement: The force requirement for operation was determined in field using spring balance and three persons involved in test (**Figure 1**). The spring balance was fixed between pulling wire and handle on pulled weeder, while another person recorded data of spring balance and third person just observed the handle of weeder along with line of action.

broad-leaved weeds (BLW) *Trianthema portulacastrum* L., *Euphorbia hirta* L.; sedges *Cyperus rotundus* L. and *Cyperus iria* L. were the important weed flora during the experimentation. The relative dominance of BLWs, grasses and sedges was recorded as 84, 11 and 5%, respectively.

Field capacity of Mandava weeder was higher (0.0168 ha/hr) than cono-weeder (0.0149 ha/hr). The lower value of effective field capacity for cono-weeder was also reported by Shakya et al. (2016). The wide difference in the values of field capacity in both the weeders may be due to difference in width of cutting parts (blades) as well as forward speed. Mandava weeder facilitates worker by providing forward push and pull action to the implement as compared to cono-weeder. Field efficiency was higher in Mandava weeder (89%) as compared to cono-weeder (87%). Higher field efficiency of weeder was because of minimum time loss in turning and depth of operation (Shakya et al.2016). Weed density of 10 and 96/m<sup>2</sup> was recorded before weeding with cono-weeder and Mandava weeder, respectively (**Table 2**). The maximum weeding efficiency was found with Mandava weeder (88%) as compared to cono-weeder (71%) which might be due to greater soil contact and soil inversion capacity of the weeder. The wide difference in the values of weeding efficiency in both weeders may be due to difference in shape of blades and depth of operation. The average value of plant damage factor for cono-weeder and Mandava weeder were obtained 7.58 and 6.1, respectively, which was 30% lower in developed country cono-weeder reported by Shakya et al. (2016). Involvement of man power was examined with respect to weeder used in controlling weeds of

under SRI and it was noted that Mandava weeder consumed the minimum man-days/ha (7.44).

**Human energy:** The highest human energy consumed by cono-weeder (131.39 MJ/ha) compared to Mandava weeder (116.65 MJ/ha). cono-weeder required the highest energy, it was found to be economical in terms of eco-energy (Table 3). But Mandava weeder was not only efficient in terms of eco-energetics but also useful completing weeding in lesser time.

**Pushing force measurement:** Result showed forces of 98°74' N and 68°64'N are required for

## I. Pushing force measurement

### flora

major weed associated with crop was grasses, broad-leaved weeds and sedges. Among grasses, *Eleusine indica* (L.) Gaertn., *Leptochloa colona* (L.) Nees, *Cynodon dactylon* (L.) Pers.;

### Weed density (no./m<sup>2</sup>) and weed control efficiency (WCE) as affected by two weeders

|                | Grasses (no. no./m <sup>2</sup> ) | Broad-leaved weeds (no./m <sup>2</sup> ) | Sedges (no./m <sup>2</sup> ) | Weed count (no./m <sup>2</sup> ) before weeding | Weed count (no./m <sup>2</sup> ) after weeding | Weeding efficiency (WCE %) |
|----------------|-----------------------------------|--|------------------------------|---|--|----------------------------|
| cono-weeder    | 71.0                              | 9.24                                     | 4.20                         | 84  | 24   | 71                         |
| Mandava weeder | 80.64                             | 10.56                                    | 4.80                         | 96  | 12   | 88                         |

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mm water depth, respectively in cono-weeder, cono and mandava-weeder; they were 89.38 N and 74.38 N, respectively (Table 4).

**Ergonomics Evaluation:** Ergonomic study was conducted with 5 male workers for weeding in SRI. Anthropometric rod and weighing balance were used to measure the physical characteristics and stop watch for recording time. Polar Heart Rate Monitor (Polar RS800CX, Finland) was used for recording heart rate during weeding. To evaluate the weeding through the ergonomic point of view, 5 workers in age group of 25-35 yrs were selected and average age as 33.8 yrs, body height of 167.8 cm and weight 66.60 kg, respectively (Table 5).

Physiological stress of weeding was determined on the basis of parameters i.e. heart rate during work, energy expenditure and cardiac cost of while performing activity (Table 6).

There was 10.4% increase in working efficiency with usage of the mandava weeder. The

output recorded by Mandava weeder was 168 m<sup>2</sup>/hr as compared to cono-weeder (149 m<sup>2</sup>/hr). During weeding with cono and Mandava weeder, AHR was 27.6 and 24.4 beats/min, respectively. Energy expenditure was 8.57 kJ/s and cardiac cost 1.08 beats/m<sup>2</sup> for cono-weeder. However, in case of Mandava weeder it was found 7.68 kJ/s and 0.96 beats/m<sup>2</sup> of energy expenditure and cardiac cost, respectively. Mandava weeder saved 21.88% cardiac cost and increases efficiency 10.38%.

## SUMMARY

Two weeding tools were evaluated in SRI. Maximum weeding efficiency was recorded by mandava weeder as compared to cono-weeder. Mandava weeder consumed minimum man-days/ha. Therefore, mandava weeder may be promoted in farmer's fields in wider scale as it reduces energy expenditure of small and marginal farming community of Indo-Gangetic Plains of the Eastern India.

## ACKNOWLEDGEMENTS

### Human energy requirement for weeders in SRI

The senior authors sincerely acknowledge to 'Sir Jamsed Ji Tata Trusts' Mumbai for technical financial support to conduct the present study.

| rice field     | Human<br>(Man-hr/ha) | Energy requirement<br>(MJ/ha) |
|----------------|----------------------|-------------------------------|
| weeder         | 67.04                | 131.39                        |
| mandava weeder | 59.52                | 116.65                        |

### Pushing force vs. water levels in ricefield

| levels | Pushing force (N) |                |
|--------|-------------------|----------------|
|        | Cono-weeder       | Mandava weeder |
|        | 196.2             | 188.58         |
|        | 98.74             | 89.38          |
|        | 68.64             | 61.14          |

### Physical characteristics of selected male farmers (N=5)

| Physical characteristic | Mean±SD     |
|-------------------------|-------------|
| Height (cm)             | 33.80±9.18  |
| Weight (kg)             | 167.80±3.96 |
|                         | 66.60±4.28  |

### Performance of male farmers during field operation (N=5)

|  | Cono-weeder | Mandava weeder |
|--|-------------|----------------|
| Working heart rate (beats/min)                 | 108.8±10.47 | 103.2±10.64    |
| Heart rate during rest (beats/min)             | 81.2±5.59   | 78.8±7.39      |
| Energy expenditure (kWh/ha)                    | 27.6        | 24.4           |
| Energy expenditure (kJ/s)                      | 149         | 168            |
| Energy expenditure (kJ/s)                      | 8.57        | 7.68           |
| Heart rate (beats/m <sup>2</sup> area covered) | 11.15       | 8.71           |
| Time in drudgery (%)                           | -           | 10.38          |
| Energy efficiency (%)                          | -           | 21.88          |

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