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

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**Short communication**

# 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 ecologies ranging from irrigated to rainfed upland, lowland 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 crop productivity as they cause a reduction of 10-90% grain yield in rice field (Kumar *et al.* 2016). System of Rice Intensification (SRI) is a modern and alternative method of rice cultivation for reduced use of seed, water and labour and to increase the crop productivity. But this system is much infested with weeds because growing under the limited water management. *Echinochloa* spp., *Cynodon dactylon*, *Portulaca 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 problematic 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 improved tools not only uproot the weeds between crop rows but also ensuring the better soil aeration. Different type of weeders are available for weeding but all these designs are location specific and designed to meet the requirement of soil type, crop grown, cropping pattern and availability of the local resources (Goel *et al.* 2008). Hence, performance of promising manual weeders was evaluated in SRI under the middle Indo-Gangetic plains.

A field experiment was conducted at ICAR Research Complex for Eastern Region, Patna (25$^o$35' N latitude and 85$^o$ 04' E longitude) during the *Kharif* 2016 to study the performance of weeders *i.e.* cono and Mandava weeder under the irrigated ecosystem. Soil of the experimental plot was clay loam (sand: 23.69%, silt: 39.64% and clay: 37%). The climate of experimental site was sub-tropical in nature exhibiting high humidity and medium rainfall. The rice cv. *'Pusa 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$^0$C and 12.2 - 23.2$^0$C, respectively. The rice seedlings were transplanted at 25×25 cm apart. The specification of the experimental weeders 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).

$$\text{Theoretical field capacity} = \frac{\text{Working width} \times \text{Speed}}{10} \quad ................(1)$$

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

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

$$\text{Effective field capacvity} = \frac{\text{Area covered by weeder}}{\text{Total time taken} \times 10000} \quad ........(2)$$

Where, Area covered in m$^2$ and total time in hr

Field efficiency: It is the ratio of the effective field capacity to theoretical field capacity and expressed in percent (%) and it was calculated by using the formula as suggested by Mehta *et al.* (2005).

$$\text{Field efficiency (\%)} = \frac{\text{Effective field capacity}}{\text{Theoritical field capacity}} \times 100 .......(3)$$

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

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

Weeding efficiency: Square loop (0.25 $m^2$) was randomly thrown to field and number of weeds including in loop was counted before and after weeding (Rangasamy *et al.*1993). Three sets of observations were taken and weeding efficiency was calculated as below.

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

Where, $W_1$= number of weeds before weeding, $W_2$= number of weeds after weeding

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

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

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

The human energy co-efficient 1.96 MJ was considered as suggested by De *et al.* (2001)

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

$$Draft = Pulling\ Force \times Cos\ \theta \text{ ................ Eqn. (7)}$$

$$Pushing\ Force = \frac{Draft}{Cos\ \theta} \text{............................ Eqn. (8)}$$

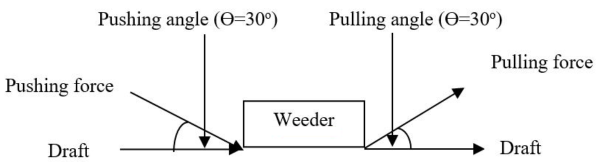


**Figure 1. Pushing force measurement**

### Weed flora

Major weed associated with crop was grasses, broad-leaved weeds and sedges. Among grasses, *Echinochloa crus-galli* (L.), *Echinochloa colona* (L.) Link, *Eleusine india* (L.) Gaertn., *Leptocholoa chinensis* (L.) Nees, *Cynodon dactylon* (L.) Pers.; broad-leaved weeds (BLW) *Trianthema, portulacastrun* L., *Euphorbia hirta* L.; sedges *viz. Cyperus rotundus* L. and *Cyperus iria* L. were 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 easy push and pull action to the implement as compared to cono-weeder. Field efficiency was higher with Mandava weeder (89%) as compared to cono-weeder (87%). Higher field efficiency of weeder was because of minimum time loss in turning and during operation (Shakya *et al.*2016). Weed density of 84 and 96/$m^2$ was recorded before weeding with the 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 and Mandava weeder were obtained 7.58 and 6.17% respectively, which was 30% lower in developed cono-weeder reported by Shakya *et al.* (2016). Involvement of man power was examined with respect to weeder used in controlling weeds of rice under SRI and it was noted that Mandava weeder consumed the minimum man-days/ha (7.44).

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

**Pushing force measurement**: Result showed that forces of 98°74' N and 68°64'N are required for 10

**Table 2. Weed density (no./$m^2$) and weed control efficiency (WCE) as affected by two weeders**

| Weeder | Grasses (no no./$m^2$) | Broad-leaved weeds (no./$m^2$) | Sedges (no./$m^2$) | Weed count (no./$m^2$) before weeding | Weed count (no./$m^2$) 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 |

and 30 mm water depth, respectively in cono-weeder, while in mandava-weeder; they were 89.38 N and 61.14 N, respectively (**Table 4**).

**Ergonomics Evaluation**: Ergonomic study was carried out 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 (RS-400, Finland) was used for recording heart rate of subject. To evaluate the weeding through ergonomic point of view, 5 workers in age group of 21 to 46 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 and rest, energy expenditure and cardiac cost of work 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 $m^2$/hr as compared to cono-weeder (149 $m^2$/hr). During weeding with cono and Mandava weeder, ÄHR was 27.6 and 24.4 beats/min, respectively. Energy expenditure was 8.57 kJ/s and cardiac cost 11.15 beats/$m^2$ for cono-weeder. However, in case of Mandava weeder it was found 7.68 kJ/s and 8.71 beats/$m^2$ of energy expenditure and cardiac cost, respectively. Manduva weeder saved 21.88% cardiac cost and increases efficiencd 10.38%.

**Table 3. Human energy requirement for weeders in SRI rice field**

| Weeder | Human (Man-hr/ha) | Energy requirement (MJ/ha) |
|---|---|---|
| Cono weeder | 67.04 | 131.39 |
| Mandva weeder | 59.52 | 116.65 |

**Table 4. Pushing force vs. water levels in rice field**

| Water levels | Pushing force (N) | |
|---|---|---|
| | Cono-weeder | Mandava weeder |
| Dry | 196.2 | 188.58 |
| 10 mm | 98.74 | 89.38 |
| 30 mm | 68.64 | 61.14 |

**Table 5. Physical characteristics of selected male farmers (N=5)**

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

**Table 6. Performance of male farmers during field operation (N=5)**

| Particular | Cono-weeder | Mandava weeder |
|---|---|---|
| Average working heart rate (beats/min) | 108.8±10.47 | 103.2±10.64 |
| Average heart rate during rest (beats/min) | 81.2±5.59 | 78.8±7.39 |
| Δ HR ( beats/min) | 27.6 | 24.4 |
| Output ( $m^2$/hr) | 149 | 168 |
| Energy expenditure (kJ/s) | 8.57 | 7.68 |
| Cardiac cost (beats/$m^2$ area covered) | 11.15 | 8.71 |
| Reduction in drudgery (%) | - | 10.38 |
| Increase in efficiency (%) | - | 21.88 |

## SUMMARY

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

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