

A novel method for manual weeding in row crops

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The weed infestation is an important biological phenomenon which reduces the crop yield even more than 45 % (Korav *et al.* 2018). Besides yield reduction, weeds also deteriorate the produce by physical presence of their seeds and debris (Riaz *et al.* 2006). Therefore, it should be controlled preferably at early crop growth stages to prevent both the quantitative and qualitative losses. In general, the weed control is done by way of mechanical, chemical or biological methods; however, a non-chemical method is preferred, as chemical methods cause damage to the ecosystem. The mechanical weeding is having added advantages of loosening of soil, soil aeration and better soil moisture conservation. Further, in mechanical methods of weeding, the weeding equipment could either be manually driven or a machine-driven. For a small farm, manually operated weeders are preferred. In India, the small and marginal farm holders are dominant with operational farm size, ranged from 0.25–2.0 ha. To these smallholders the machine operated weeder is unaffordable due to its initial cost and further the recurring expenditures. Keeping these many facts and factors in view, scientists and researchers have already developed different kinds of manual weeders but most of these are unable to weed in close vicinity of crop. The reason behind this is that the weeding components are directly attached to the handle and operated between rows, herefore, a significantly wide weed patch is left in the vicinity of plants. To address this problem, a new prototype manual weeder is developed and tested.

The prototype weeder was developed during 2013–15 and evaluated in maize crop. After modification the final prototype was fabricated in 2017–18. The different design considerations were taken like built-in adjustability facility to change in working width, push-pull mode of operation to enable the operator for temporary pause, ergonomic factros for regional suitability and adoptability, maximum walking

speed of operation to limit to 1.5 km/h for effective weeding, the weight of the weeder kept 30% of the operator's body weight, adjustable weeding blades, simplicity in design to facilitate local manufacturing to cut overall cost, to get proximity to the plant the weeder was to move over the plants and to ensure over the plants movement instead of using V shape blade, split blades was opted (Fig 1).

Based on the preceeding assumption and the design considerations a prototype manual operated weeder was developed (Fig 1). Further, the past studies have shown that, in general, the weeding is required up to 45 days of crop establishment and after thereafter crop canopy itself suppresses the resurgent weeds. On account of possible plant heights of prevailing crops in eastern region of India, the wheel's diameter of the weeder was fixed to 300 mm. The separation between the wheels was worked out to 240 mm based on possible canopy size after one month of crop establishment. The geometry of the cutting blades was based on soil-tool-plant interaction for slicing of weeds at shallow depth of 10-25 mm as the literature suggests (Bernacki *et al.* 1985). Further, the Gite *et al.* (2009) and Rangaswamy *et al.* (1993) indicated that the weight of weeder was not to exceed 30 % of 5th percentile of body weight of a farm women. Therefore, the weight of the

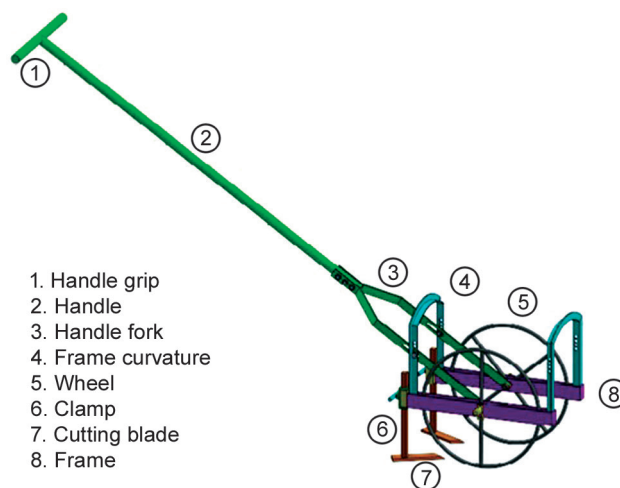


Fig 1 Schematic diagram of developed weeder.

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Table 1 Specifications of different tested weeders

Parameter	Single wheel hoe	Two wheel hoe	Developed weeder
	Manual	Manual	Manual
<i>Overall dimension, mm</i>			
Total length	1400	1700	1650
Width	475	180	250
Height	1000	1100	1000
No of cutting blades	3	1	2 (half of V blades)
Width of blade, mm	80	120	230 & 250 (adjustable)
Weight, kg	11	7.4	9.5
Diameter of wheel, mm	400	200	300
Height of handle from the ground, mm	1000	1100	1000

weeder was kept below 10 kg, as the bodyweight of farm women of this region was found to be 45±7.67 kg and the corresponding 5th percentile was 34.0 kg. Instead of men, the women criteria was implemented in design, as women constitutes a major source of farm power in crop production and related activities.

Mechanical evaluation parameters: The developed prototype weeder was evaluated along with other manual weeders such as single wheel hoe and double wheel hoe to assess the weeding efficiency, plant damage and field capacity in maize crop. The specifications of different weeders are presented in Table 1. The selection of maize crop was made for evaluation because it is cultivated round the year and grown over considerable areas across the region. The growth of maize crop is faster with considerable plant height and canopy cover compared to other crops.

Further, the field observations like operational speed, width and depth of operation, soil moisture content, etc. were recorded and analysed to determine the actual field capacity, weeding efficiency and plant damage. The number of weeds in 1 m² area was counted before the operation and the numbers of weeds left after operation were recorded and the average of such three readings was counted and taken for calculating the weeding efficiency. The weeding efficiency of each weeder was measured using the following formula (Rangasamy *et al.* 1993).

$$\text{Weeding efficiency (\%)} = \frac{W_1 - W_2}{W_1}$$

where, W₁ = No. of weeds before weeding; W₂ = No. of weeds after weeding.

The effective actual field capacity was calculated using Eqn. (Mehta *et al.* 2005)

$$\text{Effective field capacity} = \frac{A}{T_p + T_{np}}$$

where, A = Area, ha, T_p = productive time in hours and

T_{np} = non-productive time, hours.

Weeding efficiency (WC) as affected by different weeders: The weed flora of the experimental plot was diverse and the major weeds were of *Chenopodium album*, *Solanum nigrum*, and *Euphorbia hirta*. The crop was mostly affected by broad-leaved weeds, 81% followed by grasses 12% and sedges 7%. The weeding efficiency of 75%, 82% and 85% were observed with a single wheel hoe, two-wheel hoe and developed weeder and power weeder, respectively (Table 2). Shekhar *et al.* (2016) reported similar trends in maize crop with wheel hoe. The developed weeder had the maximum weeding efficiency among the three. This result could be attributed to its adjustability of cutting blade, which can easily change its direction for smooth movement as well the proximity of weeding.

Field evaluation of different weeders: The maximum plant damage was found to be 3.61% with single wheel hoe, followed by developed proto type weeder with 3.21 % and least for double wheels hoe with 1.94% (Table 2). The more plant damage with the single wheel hoe could be attributed to its high weight and imbalances during operation while the high plant damage with developed weeder could be attributed to its weeding close to the plants. The field capacity for single wheel hoe, double wheel hoe and developed weeder were of 0.0057 ha/h, 0.0089ha/h and 0.0120 ha/h, respectively. The wide difference in field capacity of different weeders was because of the width of soil cutting and speed of operation. Sarkar *et al.* (2016) reported that the field capacity of wheel hoe was 0.008 ha/hr, whereas for spade covered 0.0002 ha/hr in winter maize crop. Shekhar *et al.* (2010) was also found similar results for wheel hoe (0.009 ha/hr), grubber (0.008 ha/hr) and *Khurpi* (0.002 ha/hr).

Effect of weeders on yield attributes of maize: To assess the impact of weeding effect on biological yield, grain yield and harvest index, the selected weeders were evaluated in maize crop with the weedy check (Table 3). Interpretation

Table 2 Field evaluation of different weeders in maize

Parameter	Single wheel hoe	Two wheel hoe	Developed weeder
Initial weed density (No./m ²)	103.7	94.0	95.0
Final weed density (No. /m ²)	26	17	14
Reduction in weed density (No. /m ²)	77.7	77.0	81.0
Field capacity (ha/hr)	0.0057	0.0089	0.012
Plant damage (%)	3.61	1.94	3.21
Avg. working speed (kmph)	0.36±0.05	0.69±0.06	0.52±0.06
Avg. depth of weeding (mm)	24±4	24±2	24±4
Weeding efficiency (%)	75	82	85

Table 3 Growth and yield of maize influenced by different treatments

Treatment	Biological yield (t/ha)	Seed yield (t/ha)	Harvest Index
Single wheel hoe	8.502	3.913	0.460
Two-wheel hoe	8.402	3.950	0.470
Developed weeder	8.767	4.037	0.461
Weedy check	6.585	3.163	0.481
CD(0.05)	0.1882	0.142	0.0269

of data shows that the weeding with developed prototype weeder had significantly higher biological yield as well as grain yield compared to other manual weeders. The higher yield could be attributed to more weed control near the plants. The harvest index, however, remained almost the same for all the treatments, as 0.47. The maximum biological yield of 8.77 t/ha was recorded with developed weeder and lowest yield of 6.58 t/ha with weedy check. The corresponding grain yields were 4.03 t/ha and 3.16 t/ha, respectively.

The developed weeder unlike other available manual weeders operates over the plants and removes weeds very near to the plants. This translates into higher efficiency. The approximate cost of the weeder is ₹ 1200-1400, which is quite affordable to small farm holders. This weeder can be used for a variety of row crops and therefore would be very useful for small and marginal farmers.

SUMMARY

For small and marginal farmers the affordable weeding option is either hand weeding or simple manual operated mechanical weeder in crop production for qualitative as well as quantitative yield. Irrespective of weeding options the efficiency of weeding plays an important role in overall performance of the crop. This research paper presents a new prototype manual mechanical weeder designed and developed to take into account the anthropometric parameters of farm workers in Eastern region of India. Unlike other available manually operated mechanical weeders, this new

weeder facilitates weeding in close proximity of plants and therefore improves overall weeding efficiency. The weeder was evaluated in maize crop and its weeding efficiency in maize crop was found to be 85% with operating field capacity 0.0120 ha/h. The design components of this weeder are simple and therefore can be manufactured locally at affordable and comparable with peers at cost of ₹1200-1400.

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Corrigendum

The paper "Rana B, Parihar C M, Nayak H S, Patra K, Singh V K, Krishan P, Pandey R, Rath N, Meena B R, Kumar A, Gupta N, Sidhu H S, Jat M L. 2021. Optimization of nitrogen dose in rice under conservation agriculture based rice-wheat system with subsurface drip fertigation. *Indian Journal of Agricultural Sciences*, 91(4): 509-514 published in the April 2021 issue of **Indian Journal of Agricultural Sciences is a research article not a review paper.**