**TECHNO ECONOMIC EVALUATION OF DIFFERENT TYPES OF POWER WEEDER IN CHHATTISGARH REGION**

**ABSTRACT:**

Effective weed management is crucial in contemporary farming practices. As consumers increasingly demand high-quality, safe food products, there is a growing need for non-chemical approaches to weed control in agriculture. This shift has prompted the creation and implementation of alternative weed management techniques that reduce reliance on synthetic herbicides. Among various weeding methods, mechanical approaches are often preferred due to their timeliness, safety, reduced labour, and cost-effectiveness. In Chhattisgarh, where farm sizes per hectare per capita are diminishing over time, it is essential to develop and assess suitable mechanised weeding techniques to address farmers' needs. Hence, a study was done to examine the performance of different types of power weeder viz., power weeder 52 cc (W1), power weeder 67 cc (W2), sidepack brush cutter power weeder (W3), backpack brush cutter power weeder (W4) and solar power cum electric operated (W5) weeder were evaluated for weeding in selected crop fields i.e., mustard, cauliflower and cucumber. The findings indicated that among the power weeders, W5 achieved the highest weeding efficiency (88.6%) in mustard crops, while W1 demonstrated the lowest efficiency (73.8%) in cauliflower crops. The average plant damage percent of power weeders W1, W2, W3, W4 and W5 were found to be 1.33 %, 1.43 %, 1.33 %, 1.55 %, and 1.58 %, respectively. The highest plant damage was obtained in W5 and lowest seen in weeder W1 and W3. The weeder W5 had the highest effective field capacity of 0.042 ha/h, while weeder W1 had the lowest effective field capacity of 0.030 ha/h. The field efficiency of weeders in three different crop fields was found to be highest in Weeder W3 (85 %) and lowest in Weeder W1 (79.3 %). The performance index of solar power cum electric operated weeders was found to be the highest (357), while the power weeder 67 cc had the lowest value (95). The initial cost of weeder W5 is highest compared to other weeders. However, variable cost of weeder W5 is low as compared to other selected power weeders. The total operational cost (Rs/ha) of power weeder W1, W2, W3, W4 and W5 are 2744.1 Rs/ha, 2611.3 Rs/ha, 2513.9 Rs/ha, 2450.8 Rs/ha and 952.5 Rs/ha respectively. The required total operational energy of weeder W1, W2, W3, W4 and W5 are 1643 MJ/ha, 2083 MJ/ha, 1137 MJ/ha, 983 MJ/ha and 3685 MJ/ha. The highest energy required for weeding was observed in weeder W5 and lowest was obtained in W4.

**Keywords:** weeding, power weeder, weeding efficiency, performance index

**INTRODUCTION**

Agriculture remains a crucial pillar of rural economies in the developing world, providing livelihoods for a significant portion of the population. This sector is particularly important in India, where it accounts for the employment of roughly 46% of the total workforce (Indian Economic Survey, 2022). Beyond providing employment opportunities, this sector is crucial in addressing food security concerns for the world's growing population. Enhancing agricultural productivity per unit is crucial for maintaining long-term food security and ensuring farming remains financially viable.

Estimates suggest that the Earth's population will reach 10 billion individuals by 2050 (FAO report, 2022). It can be difficult to ensure food security for such a large population, given that the land under agriculture is drastically declining worldwide as a result of numerous reasons, including climate change. Therefore, a multifaceted strategy is needed to address the variety of issues facing the agriculture industry in order to modernise and develop it. Challenges in farm mechanisation are small plot size, lack of market access, low bargaining power in the market, Limited access to mechanisation (FICCI report, 2024). The growth of Indian agriculture is significantly hindered by limited access to farm mechanization. As a result, initiatives are in progress to address these obstacles and enhance the viability of agriculture for small-scale and marginal farmers. The implementation of farm mechanization can significantly enhance the profitability of agricultural activities by boosting productivity and reducing overall expenses.

The eradication of weeds presents numerous obstacles and effects on agricultural productivity. These unwanted plants significantly hinder farmers' progress by consuming an excessive amount of their time. Weeds, essentially undesirable vegetation, vie with crops for sunlight, water, and nutrients, ultimately reducing overall crop yields. The impact of weeds on harvest quantities varies depending on the specific crop and geographical location, with estimated reductions ranging from 16 to 42% (Kushwaha *et al.,* 2002). The extent of crop damage is affected by weed characteristics, including their species, abundance, emergence timing, and removal rate (Shekhar *et al.,* 2010). Manual weed removal is a time-consuming and often ineffective process, frequently postponed and sometimes impractical due to unsuitable soil conditions (Kumar *et al.,* 2017). Hand weeding accounts for one-third of cultivation expenses and necessitates a significant workforce, comprising about 25% of the total labour required, which equates to roughly 900-1200 person-hours per hectare (Devojee *et al.,* 2020).

Weed control through mechanical means offers multiple benefits beyond just eliminating weeds between crop rows. It also enhances soil conditions by loosening the surface, which improves air circulation and water penetration (Bini Sam, 2014). Mechanical method is often preferred over alternatives for several reasons. Optimal crop yield is dependent on proper seed placement depth and row spacing, as these factors significantly impact plant performance (Manuwa *et al*. 2009). While chemical weed control is an option, it is generally less desirable due to its high cost, potential hazards, and selective nature. In contrast, mechanical weeding techniques create a soil mulch by keeping the surface loose, which leads to improved aeration and helps conserve water from runoff (Duraisamy and Tajuddin, 1999). Tractor-driven weeding tools can save roughly 75% of the time and 20% of the cost compared to bullock-drawn techniques. However, there is uncultivated land, and the cost of hiring a tractor will be an essential input that varies with the season. Heavy soils may also experience compaction from tractor tires, which can impact subsequent crops if weeding is done frequently with tractor-drawn equipment (Mayande *et al*., 2004). The cost of operating an engine-powered weeder is only one-third that of manual labour, making it a viable method for row crops to mechanically eradicate the weed population between rows (Tajuddin, 2006). Simple, practical and affordable, row crop weeders are ideal for small and medium-sized farmers. It is also a good step in the direction of less labour-intensive in row crop weeding (Olawale and Oguntunde, 2006).

One of the essential management techniques that has a proportional impact on preserving soil moisture and reducing nutrient loss in rainfed areas is weeding and intercultural operations, which ultimately have a major impact on crop yield. Manual weeding is labour-intensive, often inefficient due to timing issues, and sometimes impractical because of unfavourable soil conditions. Among all weeding techniques, mechanical weed control is recommended for a number of reasons. The secret to increasing yield in planting crops at the right depth and spacing. A small, lightweight, self-propelled multipurpose weeder is judged to satisfy the needs of farmers in this area based on the information above and future demands to overcome the limitations of weeding in different crops. Where the average farm size per person, measured in hectares, is extremely small and steadily decreasing. In order to satisfy farmer demand, appropriate mechanised weeding techniques must be developed.

In developing nations, agricultural sectors form the backbone of their economies, with rising populations driving the demand for increased farm productivity. This has prompted governments and various organizations to implement programs aimed at enhancing agricultural mechanization. As a consequence, experts predict growth in the global market for power weeders. The Indian government launched the Sub Mission on Agricultural Mechanisation (SMAM) scheme under the Ministry of Agriculture and Farmers Welfare in 2014-15. By establishing Custom Hiring Centres (CHCs), hubs for high-tech and valuable farm equipment, and farm machinery banks, the program seeks to reach the unreached by making farm machines available and affordable for small and marginal farmers. One of the activities under the program is the distribution of various subsidized agricultural machines and equipment to individual farmers (PIB report, 2021). Additionally, the Indian government has established an ambitious goal of increasing farm power availability nationwide to 4.0 kW/ha by 2030(Kumari *et al*., 2023). Now a days, a diverse range of mechanical weeders are utilized, which can be classified into three categories. These are self-propelled power weeders, animal-drawn weeders, and tractor-drawn weeders. However, due to limited awareness about mechanical weeders, many farmers still prefer manual weeding methods. Self-propelled power weeders offer several advantages over tractors for mechanical weeding, particularly for small-scale farmers. These devices are more cost-effective, compact, and versatile across various crop fields. In recent years, numerous user-friendly power weeders with straightforward operations have entered the market. A power weeder is a two-wheeled agricultural implement equipped with weeding attachments, requiring the operator to walk behind it for guidance. These machines are employed after crop emergence to eliminate weeds, aerate and pulverize the soil, and reduce soil compaction. Power weeders are especially beneficial in hilly or sloping areas where tractor operation can be challenging. Their lightweight design allows for easy maneuverability on small farms and results in less soil compression compared to heavier tractors.

Mechanical weeders that run on gasoline or diesel are more efficient than those that use bullocks. A compact, self-propelled weeder with multiple functions is considered ideal for farmers in the region. The introduction of affordable, versatile weeders with various blade configurations will benefit small-scale and marginal farmers by enhancing work efficiency, reducing labour time and drudgery, lowering cultivation expenses, and boosting crop yields (Khayer *et al*., 2024). The popularity and demand for power weeders are growing, with various models now available. Modern power weeders come in different sizes, with varying engine capacities, weeding mechanisms, and working widths. This paper examines the testing and performance evaluation of different types of available power weeders to determine their suitability for different crops and assess their effectiveness in real field conditions.

**MATERIALS AND METHODS**

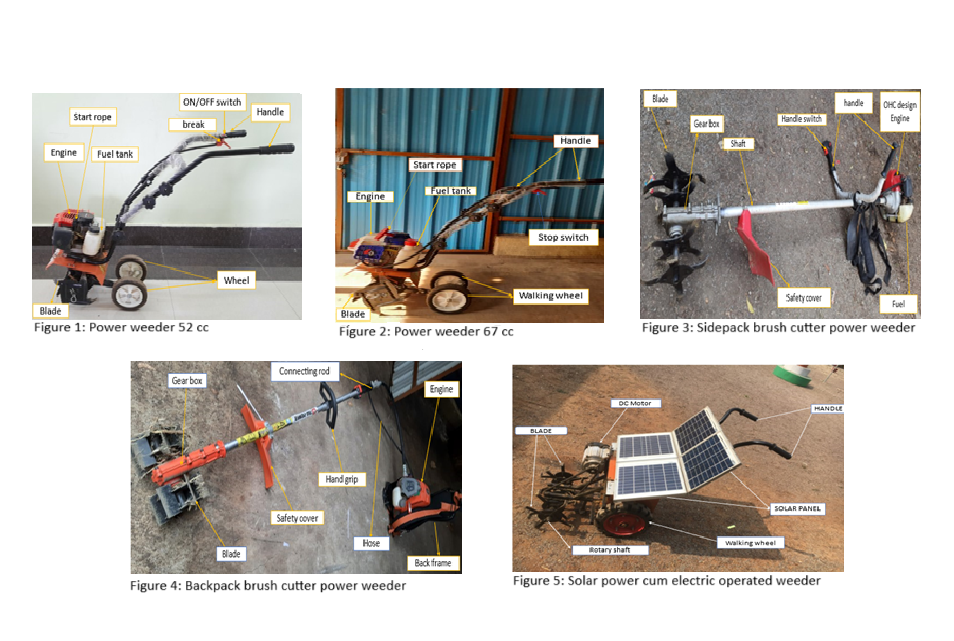
The testing of weeders was carried out in the research field of SVCAET & RS, FAE, IGKV, Raipur (C.G.) during the summer season in the year 2021-2022. The power weeder was evaluated in the fields of mustard, cauliflower and cucumber.

Mustard seeds were planted in a 900 m2 area having a spacing of 0.48×0.05 m, cauliflower was planted in a 900 m2 area, having a spacing of 0.50 ×0.50 m and cucumber was planted in a 900 m2 area having a spacing of 0.80×0.09 m was maintained.

To assess and quantify the relative effectiveness of different weeding machinery, a field experiment was conducted at the research field of Indira Gandhi Krishi Vishwavidyalaya, Raipur. The details of selected five different power weeders is shown in Table 1.

**Table 1: Details of selected power weeders**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Parameters** | **Power weeder 52 cc Engine**  **(W1)** | **Power Weeder 68 cc Engine (W2)** | **Sidepack Brush Cutter Power Weeder (W3)** | **Backpack Brush Cutter Power Weeder (W4)** | **Solar Power Cum Electric Operated Weeder (W5)** |
| Power, hp | 2 hp | 3hp |  |  | 0.938hp |
| Fuel type | Petrol + oil | Petrol + oil | Petrol + oil | Petrol | Battery (12 V, 30 amps) |
| Fuel tank capacity | 1.2 L | 1.35 L | 1 L | 1.2 L | - |
| Engine Type | 2- Stroke | 2- stroke | 2- stroke | 4- stroke | - |
| Engine (RPM) | 6500 rpm | 6500 rpm | 7000 rpm | 12000 rpm | 480 rpm |
| Type of blade | Curved strip type blade | Curved strip type blade | Tiller type blade | Rotor type blade | L type shape |
| No. of blades | 16 | 16 | 16 | 12 | 16 |
| Cutting Width | 250-300 mm | 250-300 mm | 280-320 mm | 200-240 mm | 400-460 mm |
| Cutting Depth | 45-60 mm | 45-60 mm | 40-80 mm | 20-40 mm | 30-45 mm |
| Price | ₹ 12,500 | ₹ 18,500 | ₹ 10490 | ₹ 12,000 | ₹ 55,040 |

**3.1 Experimental Design**

The experimental data collected on various aspects were tabulated and analysed statistically by using the technique of analysis of variance for split-plot design and significance was tested by F-test. The independent and dependent parameters of the weeder were analysed by split-plot design. The summarised details of the experiment are shown in Table 2,3.

**Table 2: Plan of experiments on test setup**

|  |  |
| --- | --- |
| Factor A: Crops (3)  C1: Mustard crop  C2: Cauliflower crop  C3: Cucumber crop | Factor B: Weeder (5)  W1: Power weeder 52 cc Engine  W2: Power weeder 67 cc Engine  W3: Sidepack brush cutter power weeder  W4: Backpack brush cutter power weeder  W5: Solar power cum electric operated weeder |
| Design | Split plot design |
| Replication | 4 |
| Number of plots | 3 |
| Number of sub-plots | 15 |
| Number of treatments | 15 |

**Table 3: Identification of treatments**

|  |  |
| --- | --- |
| Crop | Treatment |
| Mustard (C1) field | T1(C1W1), T2(C1W2), T3(C1W3), T4(C1W4), T5(C1W5) |
| Cauliflower (C2) field | T6(C2W1), T7(C2W2), T8(C2W3), T9(C2W4), T10(C2W5) |
| Cucumber (C3) field | T11(C3W1), T12(C3W2), T13(C3W3), T14(C3W4), T15(C3W5) |

**3.2 Operational Parameters for Testing of Weeder**

The following operational parameters were determined:

**3.2.1 Moisture content of soil**

To determine moisture content of soil, soil sample were taken up to a depth of 10 cm. The samples were collected randomly from three locations of test plot before a day of weeding in the field. These samples were weighed and kept in an oven at 105±50°C for 24 hours.

**3.2.2 Bulk density of soil**

To determine bulk density of soil, core sampler having 50 mm diameter and 300 mm length, marked at each 10 mm interval along its length was used. Firstly, it was vertically inserted into the soil up to 50 mm only and the soil was collected in it was removed immediately as the first sample. Same procedure was repeated for collection of three sample from random locations. Samples were weighed and kept in the oven at 105 ± 5 °C for 24 hours.

**3.2.3 Plant population**

To determine plant damage percentage, the total number of plants was counted in a 10 m row length from randomly selected locations in each plot before and after each weeding operation.

**3.2.4 Weed population**

Before and after each weeding operation, the total number of weed plants were counted in an area of one square metre using a quadrate, from randomly chosen location in each plot.

**3.2.5 Effective working depth**

In the field, the depth of cut of the machine was measured by measuring the depth of soil layer tilled by the blade in a row. The depth of the weeding was measured using a measuring scale in various locations. The depth of weeding was calculated as the average of five observations and expressed in centimetres.

**3.2.6 Effective working width**

To measure effective working width of machine in field using concept of tilled and untilled strip from the original selection in between rows.

**3.3 Evaluation of Performance Parameters of Weeders**

The following machine performance parameters were calculated on actual field condition from the field data:

**3.3.1 Operating speed**

Two poles were placed at a distance of 30 m apart, and a weeder was operated between them, with the crossing time between these two poles measured. The forward speed of operation is calculated by observing the distance travelled and the time required to cover these two poles.

**3.3.2 Weeding efficiency**

Weeding efficiency is a percentage that is calculated by dividing the number of weeds removed by a weeder by the number of weeds present in a unit area (Tajuddin, 2006).

**3.3.3 Plant damage**

It was calculated by using the following formula (Tewari *et al.,* 1993).

Where,

q = Number of plants in a 10 m row length after weeding, and p = Number of plants in a 10 m row length before weeding.

**3.3.4 Theoretical field capacity**

It is measured in hectare per hour and is expressed as follows (Kepner *et al.*, 1978)

Where,

TFC = Theoretical field capacity, ha/h, w = cutting width, m and s = speed of operation, Km/h.

**3.3.5 Effective field capacity**

The actual covered area during operation was called effective field capacity (Kepner *et al*., 1978).

Where,

EFC = effective field capacity, ha/h, A = area, ha, Productive time, h, and Tl = non-productive time, h.

**3.3.6 Field efficiency**

It is the ratio of actual field capacity to theoretical field capacity and is expressed as percentage. It includes the effect of time lost in the field and the failure to utilize the full width of machine (Kumar *et al*., 2018).

Where,

Field efficiency, %, EFC = Effective field capacity, ha/h, and TFC = Theoretical field capacity, ha/h.

**3.3.7 Fuel consumption**

The fuel consumption of power weeder was measured by top fill method. In this method, fuel tank was filled up to top level before testing. After completing of test operation, the fuel tank was filled up again. The difference of two observations gave the fuel consumed in the concerned operations and was expressed in litre per hour.

**3.3.8 Performance index of weeder**

Performance index is a measurement of performance of a weeder and is directly related to the field capacity, plant damage and weeding efficiency and inversely related to power exerted. Following relation as suggested by Srinivas *et al*. (2010).

Where,

FC = Field capacity, ha h-1, PD = Plant damage, %, WE = Weeding efficiency, %, and P = Power, hp.

**3.3.9 Operational cost**

The operational cost of power weeders by accounting fuel consumption, Labour charges per day, Lubrication cost, Repair and maintenance of machine. These expenses are incurred only when the machine is used. Cost of weeding operation of power weeders was calculated in Rs. ha-1.

**RESULTS AND DISCUSSION**

**4.1 Operational Parameters for Testing of Weeders**

**4.1.1 Moisture content of soil**

The average moisture content of mustard field (C1), cauliflower (C2) and cucumber (C3) are found as 27.3 %, 22.1 %, 19.3 % respectively on dry basis.

**4.1.2 Bulk density of soil**

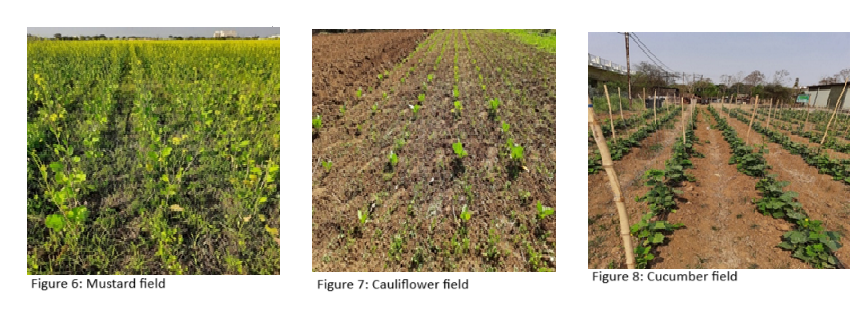
The average soil bulk density of mustard field, cauliflower and cucumber is found as 1.15 g/cm3, 1.24 g/cm3, 1.27 g/cm3 respectively.

**4.1.3 Plant population**

The number of plants counted in a 10 m row length was found to be the maximum in mustard crop fields is 166 and the least number of plants is seen in a 10 m row length in cauliflower is 20.

**4.1.4 Weed population**

The grasses dominated over broad-leaved weeds and sedges in mustard fields among other crop fields. The broad-leaved weeds dominated over grasses and sedges in cauliflower and cucumber field.

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**4.1.5 Operating speed**

The operating speed of different power weeder was determined by noting down the time required to cover 30 m of weeding length. Amongst power weeders (W1, W2, W3, W4 and W5), the highest speed of operation (1.8 km/h) was obtained in W2 and W3 power weeder at treatment T2 and T8 respectively. The power weeder 67 cc engine (W2) provides cutting width, cutting depth, rpm and power is 250-300mm, 45-60 mm, 6500 rpm and 3hp respectively and the sidepack brush cutter power weeder(W3) provides (2 hp) engine power, (7000 rpm) blade speed, (280-320 mm) cutting width, (40-80 mm) cutting depth. Therefore, which tills the soil with high-speed rotating blades. The weeder W1, W2 and W3 are having almost same speed of operation. The lowest operating speed (1.2 km/h) was obtained in Solar power cum electric operated weeder (W5). This weeder provides (1.05 hp) engine power, (480 rpm) blade speed, (400-460 mm) cutting width and (30-45 mm) cutting depth.

**4.1.6 Theoretical field capacity**

The theoretical field capacity, computed based on the forward speed and the cutting width of weeder. Assuming the machine is using its full width. The highest value of theoretical field capacity is 0.051 ha/h was found in solar power cum electric operated weeder(W5) while, the least value is 0.037 ha/h was found in power weeder 52 cc (W1). The actual working width of weeder (W5) and (W1) is 400 mm and 250 mm respectively. The row to row spacing of crop C1, C2 and C3 is 0.48 m, 0.50 m and 0.80 m respectively. Thus, the weeder W5 covers almost row width area of Cauliflower field (C2) and its showed maximum value (0.055 ha/h) of theoretical field capacity at treatment T10.

**4.1.7 Effective field capacity**

The effective field capacity of weeders with different row to row spacing on different crop was determined. The maximum effective field capacity 0.042 ha/h was found in weeder W5 and minimum value 0.030 ha/h was seen in weeder W1. The results proven solar power cum electric operated weeder (W5) covers almost row width area of cauliflower crop and least row width area of crop per unit time covered by power weeder 52cc (W1). The highest value of effective field capacity of weeder W5 is 0.047 ha/h was found in treatment T10.

**4.1.8 Field efficiency**

The mean value of field efficiency of weeder in three different crop field was found highest in Weeder W3 (85 %) and lowest was observed in weeder W1 (79.3%). The backpack brush cutter power weeder showed maximum field efficiency 89.1 percent (W3) in treatment T9 was observed at 35.25 mm depth of cut, 231.5 mm effective working width with operating speed 1.6 km/h at 0.50 m row spacing between plants in crop C2. Where the minimum field efficiency 73.6 % was found in power weeder (W5). The power weeder 67 cc (W2) is almost same field efficiency of power weeder 52 cc (W1).

**4.1.9 Fuel consumption**

The fuel consumption of selected power weeders was measured using top fill method. It was found that variation occur in fuel consumption of power weeder W1, W2, W3 and W4 at different test condition. The maximum fuel consumption (0.63 l/h) was found in power weeder 67 cc (W2). This power weeder provides 3 hp engine power is highest among other power weeders. The engine power is directly proportion to fuel consumption. Hence, more fuel consumed in weeder W4. Whereas, the minimum fuel consumption (0.45 l/h) was found in backpack brush cutter power weeder (W4). This weeder provides 4-stroke petrol engine which consumes less fuel compares to 2-stroke engine. The weeder W1, W2 and W3 is a 2-stroke petrol engine. These weeders consume more fuel compared to 4-stroke engine weeder. The average fuel consumption of W1, W2, W3 and W4 is 0.50 l/h, 0.63 l/h, 0.50 l/h and 0.45 l/h respectively.

**4.1.10 Weeding efficiency**

Weeding efficiency of a power weeder was observed under various weeding conditions. The average weeding efficiency of power weeder W1, W2, W3, W4 and W5 is 76.9 %, 82 %, 83.1 %, 79.2 % and 86.4 % respectively. The weeding efficiency of power weeder 67 cc and sidepack brush cutter power weeder is almost same. The mean highest weeding efficiency was found in weeder W5 is 86.4 % and lowest weeding efficiency was observed in weeder W1 (76.9 %). The maximum value of weeding efficiency of weeder W5 is 88.6 % at treatment T5 and minimum value of weeding efficiency of weeder W1 is 73.8 % at treatment T6. The weeder W5 shows highest weeding efficiency because of its highest cutting width of blade, it covers almost row length area of mustard crop (C1) in treatment T5. The weeding efficiency depends on weed flora, weed intensity, effective working width, effective working depth and soil moisture at the time of weeding.

**4.1.11 Plant damage**

The highest plant damage (1.81 %) was observed in backpack brush cutter weeder (W4) in cucumber (C3) field at treatment T14. whereas lowest (0.90 %) seen in sidepack brush cutter power weeder (W3) in cucumber (C3) field at treatment 13. The average plant damage percent of weeder W1, W2, W3, W4 and W5 is 1.33 %, 1.43 %, 1.33 %, 1.55 % and 1.58 %.

**4.1.12 Performance index of weeder**

Fig. 9: Variation of performance index of weeders in different crop fields

**4.1.13 Operational cost**

Fig. 10: Variation of operational cost of weeders

**Table 4: Performance characteristics of weeders**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| S. No. | Parameters | Power weeder 52 cc | Power weeder 67 cc | Sidepack brush cutter power weeder | Backpack brush cutter power weeder | Solar cum electric operated weeder |
| 1 | Operating speed | 1.6 | 1.6 | 1.5 | 1.4 | 1.2 |
| 2 | Effective field capacity | 0.029 | 0.035 | 0.036 | 0.033 | 0.042 |
| 3 | Theoretical Field capacity | 0.037 | 0.044 | 0.043 | 0.039 | 0.051 |
| 4 | Field efficiency | 79.2 | 79.5 | 85.0 | 83.0 | 81.1 |
| 5 | Weeding efficiency | 76.9 | 81.9 | 83.1 | 79.2 | 86.3 |
| 6 | Plant damage | 1.3 | 1.4 | 1.3 | 1.5 | 1.5 |
| 7 | Performance index | 112.3 | 94.5 | 151 | 129 | 357 |
| 8 | Average Fuel consumption | 0.56 | 0.62 | 0.49 | 0.47 |  |

**CONCLUSIONS**

Solar power cum electric operated weeder was found suitable for weeding in vegetable crops with higher weeding efficiency (86.4 %) and lower operational cost (952.5 Rs/ha) obtained in solar powered weeder. It is recommended for use in mustard and cauliflower fields.The brush cutter weeder performance was also found satisfactory and so it is recommended for cauliflower and mustard crops including weeding in hilly area cultivation.

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**REFERENCES**

Bini S. Development and physiological cost evaluation of a modified blade system for power weeder in dry land cultivation. *International Journal of Scientific Engineering and Research*. 2016;4(1).

Devojee B, Meena S, Sharma A, Agarwal C. Performance evaluation of weeder by number of blades per flange in chilli crop. *International Journal of Chemical Studies*. 2020;8(2):727-731.

Duraisamy, V.M and Tajuddin, A. 1999. Rotary weeder for mechanical interculturing in sugarcane. Agro India., 3(1-2): 48

FAO, FAOSTAT 2022, Employment indicators: Agriculture; <https://www.fao.org/faostat/en/>

FICCI, 2024, Farm mechanisation: A catalyst for sustainable agricultural growth. Retrieved from <https://www.pwc.in/assets/pdfs/consulting/management-consulting/farm-mechanisation-catalyst-sustainable-agricultural-growth.pdf>

Government of India. (2023). Economic Survey 2022-23. Ministry of Finance, Government of India. Retrieved from <https://www.indiabudget.gov.in>

Kepner, R. A., Bainer, R. and Barger, E. L. 1978. Principles of farm machinery, 3rd edition, AVI publication Co., INC., Westport, Connecticut.

Khayer, S.M., Patel, T., Rahman, B. and Ahmed, P., 2024. Performance evaluation of power weeder with different blade mechanism in intra-row weeding operation*. Archives of Current Research International*, 24(2), pp.39-49.

Kumar GK, Kumar DA, Sean YD. Performance evaluation of power weeder under dry and wet land conditions. *International Journal of Agriculture Innovations and Research*. 2017;6(2):222-223

Kumar, G. K., Kiran, B. R. and Krishna, C. M. 2018. Performance and evaluation of power weeder, wheel hoe, star weeder under dryland conditions. *International Journal of Current Microbiology and Applied Sciences*. 7(12): 1669-1675.

Kumari, A., Singh, S., VP, A., Joshi, P., Chauhan, A.K., Singh, M. and Hemalatha, S., 2023. Mechanization in Pre-harvest Technology to Improve Quality and Safety. In *Engineering Aspects of Food Quality and Safety* Cham: Springer International Publishing. pp. 93-114.

Kushwaha HS, Tripathi ML, Singh VB. Weed management in coriander (Coriandrum sativum). In Proceedings of the Second International Agronomy Congress on Balancing Food and Environment Security: A Continuing Challenge. 2002:985-987.

Manuwa SI, Odubanjo OO, Malumi BO, Olofinkua SG. Development and performance evaluation of a row-crop mechanical weeder*. Journal of Engineering and Applied Sciences.* 2009;4(4):236-239

Mayande, V.M., Srinivas, I. and Adake, R.V. 2004. Mechanical weed control in drylands. Mission Mode Project on Dryland Mechanization, pp 1-10

Olawale, J.O. and Oguntunde, P. 2006. Design of power weeder. Conference on International Agricultural Research and Development “Tropentag 2006”. University of Bonn. Germany.

PIB, 2021,Initiatives of Government of India to Promote Farm Mechanization. Retrieved from <https://pib.gov.in/Pressreleaseshare.aspx?PRID=1696224>

Shekhar S, Chandra S, Roy DK. Performance evaluation of different weeding tools in maize. *Indian Journal of Weed Science*. 2010;42(1&2):95-97.

Srinivas, I., Adake, R. V., Reddy, B. S., Korwar, G. R., Thyagaraj, C. R., Dange, A., Veeraprasad, G. and Reddy, C. R. 2010. Comparative performance of different power weeders in rainfed sweet sorghum crop. *Indian Journal Dryland Agriculture Research and Development*. 25(2): 63-67.

Tajuddin, A. 2006. Design, development and testing of engine operated weeder. *Agricultural Engineering Today*. 30(5): 25-29.