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Performance evaluation of battery operated single row weeder for chickpea

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Abstract
Battery operated single row weeder was evaluated for its performance in chickpea crop. This test was conducted at different type of blade, speed and depth of cut of weeder. The effective field capacity of battery operated single row weeder was varied from 0.046 to 0.026 ha/h at 1.5 to 2.0 km/h forward speeds at 25-30 DAS. The weeding efficiency of battery operated single row weeder with 1.5 to 2.0 km/h forward speeds, C- type, J-type and L-type blade at 30-50 mm depth of cut were varied in the range of 82.75% to 90.24%. The minimum plant and maximum plant damage was observed at a L-type and J- type blade, respectively.

Keywords: Battery weeder, speed, field capacity, plant damage, weeding efficiency, depth of cut

Introduction

Chickpea is a significant pulse crop from the perspective of the country's expanding food basket. *Cicer arietinum*, as it is known scientifically, is a member of the Leguminosae family. Globally, Bengal gram is grown on an area of 137 lakh hectares with a yield of 142.4 lakh tonnes and productivity of 1038 kg/ha (FAO data, 2019). India produces 70 percent of the world Bengal gram production of 116.2 lakh tonnes cultivated under 112 lakh hectares with yield of 1036 kg/ha in 2020-21 (agricoop.nic.in). With a productivity of 990 kg/ha, 331.68 thousand tonnes of chickpeas are produced in Chhattisgarh on 335.03 thousand hectares of land.

In chickpeas, weed infestation offers intense competition and reduces yield by 75% (Chaudhary *et al.* 2005) [5]. For weed crop competition in chickpea, the first sixty days are thought to be crucial (Singh and Singh 1992) [8]. Chickpea crop is not a competitive crop, especially when weed competition occurs at early stages (Barker, 2017) [3]. Yield losses caused by weeds in chickpeas have been estimated at 40 to 87 per cent in India, 41 to 42 per cent in the former Union of Soviet Socialist Republics (USSR) and 23 to 54 per cent in West Asia (Bhan and Kukula, 1987) [4]. However at Indian Institute of Pulses Research, yield losses due to weed in chickpea varied between 29-70 per cent over the years (Anonymous, 2009) [2]. The cost of labor has increased, and there is a labor shortage, making manual weed management more challenging. Farmers must use an appropriate herbicide to effectively control the mixed weed flora in order for this crop to be better adopted; nevertheless, the main issue is the lack of suitable post-emergence herbicide for chickpeas.

The mechanical power source has need adopted in farm operation, due to its higher efficiency, these sources primarily run on fossil fuels. The use of fossil fuel increases the CO_2 emission which has adverse effect on environment. In future it is, therefore, necessary to establish a bond between the opportunity of sustainable development of agricultural mechanization without neglecting the lack of energy and environmental degradation due to low availability of fossil fuels and its adverse effect on environment. Application of battery energy in farm land for different agricultural operations could reduce the cost of operation without deteriorating the quality of environment. The main motive of this weeder to provide less costly machine to the farmer to better growth. It is less costly and time saving device for the farmer. It should consume minimum possible power compared to other weeding machines. It should have flexibility for use in rows of different width.

Materials and Methods

Performance evaluation of developed battery operated single row weeder was carried out at Farm of Krishi Vigyan Kendra, Pahanda (A) Durg, (C.G.) as well as at farmers field with commonly grown row crop like Chickpea in accordance with standard procedure and guidelines prescribed. The battery operated single row weeder was evaluated at 25-30 days after sowing and with different type of blade viz. C-type, J-type and L-type, forward speeds 1.5 km/h to 2.0 km/h at different depth of cut *i.e.* 30-50 mm. The details of experimental methodology and measurement techniques adopted during the research were described in the following sections.

The prototype battery operated single row weeder consisted of main frame, battery, motor, power transmission, rotary unit, rotary weeding unit, handle assembly, safety cover and transport wheel. Parts of the developed battery operated single row weeder are shown in Fig.1. The entire machine setup has many an important component among which frame was considered as an important part. Top end of the frame has a handle to hold and move the machine and bottom part of the frame holds motor and two wheels were fixed with the help of locking pin. To power transfer was established using chain and sprocket mechanism. The very important part of the entire machine setup was weeder blades which have high impact on the weeding operation and have the contact directly with the soil. There was different shapes of blades viz. C shaped blades, J shaped blades, and L shaped blades were tested to the field to find out the best solution for weeding operation.

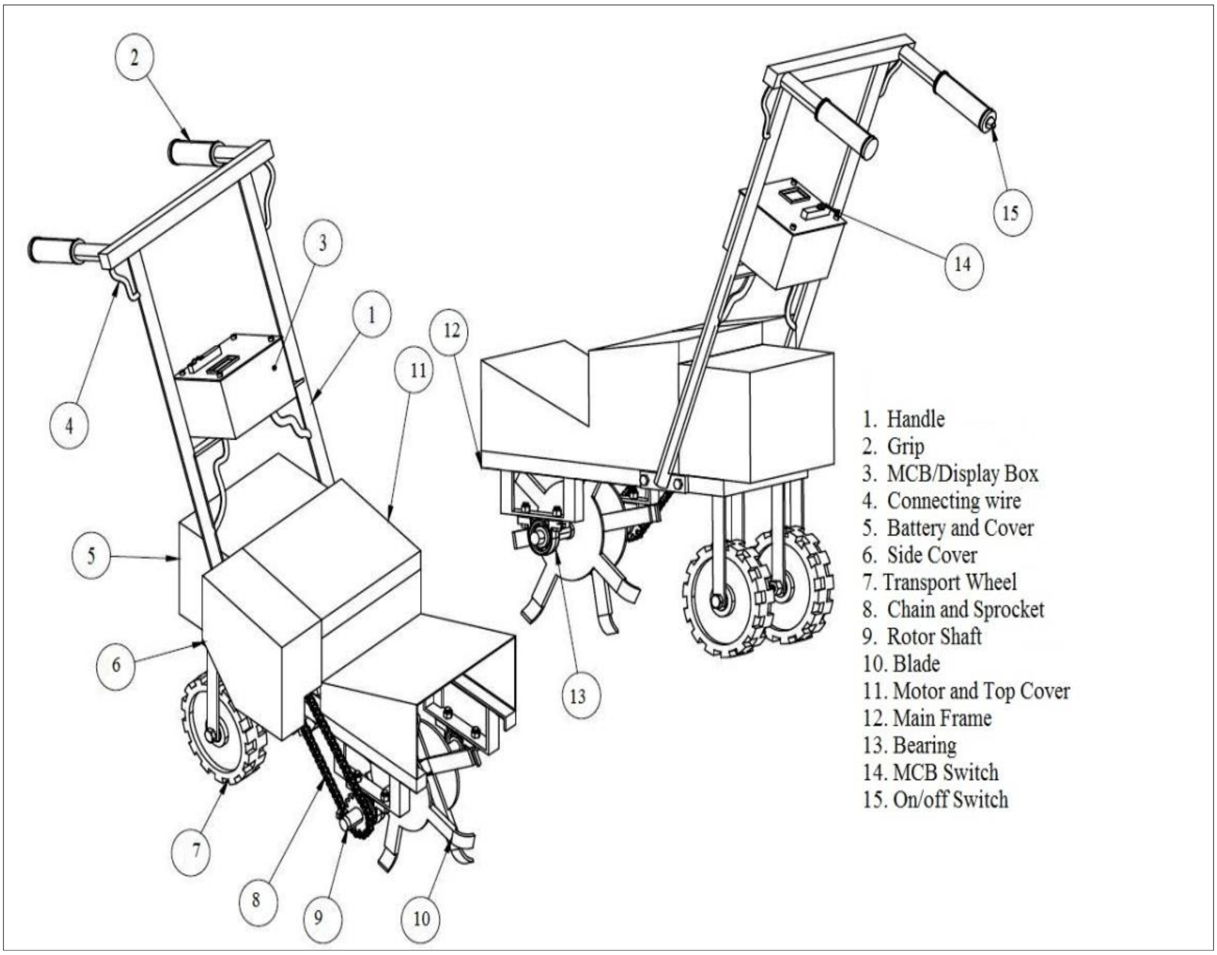

Fig 1: Parts of the developed battery operated single row weeder

The soil of the experimental farm is classified as vertisol group having clay. The row to row spacing of the chickpea crop under the study, were measured on 25 to 30 DAS at 10 places at random and tabulated. The results were statistically analyzed and presented in Table 1.

Table 1: Row spacing of chickpea crop

Crop	Row spacing, mm			
	Min.	Max.	Average	SD
Chickpea	287	321	305	9.20

Evaluation of Performance Parameters

Weed density

Weed density measures the number of the species in a unit area, sometimes expressed as a percentage.

Weed population

The total numbers of weed plants were counted in an area of one square meter by using square meter and those places were chosen randomly in each plot before and after every weeding operation.

Effective working depth

The depth of weeding operation was measured by measuring scale in different rows at different places.

Effective working width

The width of cut of the machine was measured in the field by standard method using concept of tilled and untilled strip from the original selection in between rows.

Theoretical field capacity

Theoretical field capacity of the machine is the rate of field coverage that would be obtained if the machine were performing its function 100% of the time at the rated forward speed and always covered 100% of its rated width. It is expressed as hectare per hour and determined as follows (Kepner *et al.*, 1978) [6].

$$TFC=\frac{w \times s}{10}$$

Where,

TFC = Theoretical field capacity, ha/h;
w = Width of cut, m; and
s = Speed of operation, km/h.

Field efficiency

Field efficiency is the ratio of effective field capacity to the theoretical field capacity, expressed as percentage. It includes the effect of time lost in the field and of failure to utilize the full width of the machine (Shahare *et al*., 2020) [7].

$$\eta_e=\frac{EFC}{TFC}\times 100$$

Where,

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

Weeding efficiency

The weeding efficiency of the weeder will be calculated using the following equation (Yadav and Pund, 2007) [10].

$$W_e=\frac{W_1-W_2}{W_1}\times 100$$

Where,

We = Weeding efficiency, %;
W_1 = Count of weeds between two rows before weeding; and
W_2 = Count of weeds between two rows after weeding.

Plant damage percentage

The plant damage percentage by weeder will be calculated using the following equation (Srinivas *et al.*, 2010) [9].

Plant damage percentage, $q = (Q / p) \times 100$

Where,

q =Plant damage, percent;
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.

Performance index

The performance of the weeder will be assessed through performance index with suggested by Srinivas *et al.*, (2010) [9].

$$PI=\frac{(a \times (100-q) \times e}{P}$$

Where,

PI = Performance index,
a = Field capacity of weeder, ha/h;
q = Plant damage, percent;
e = Weeding efficiency, percent; and
P = Power input, hp.

Results and Discussion

The performance of battery operated single row weeder for chickpea crop with different type of blade, speed and depth of cut was evaluated under field conditions. In this chapter, results were presented. Weeder parameters like field capacity, field efficiency, weeding efficiency, plant damage and performance index for weeder were discussed. The battery operated single row weeder is easy to operate in a row crop for weeding up to the depth of 50 mm. Due to the adjustable row spacing, this designed weeder is not limited to single crops; it may also be used for various line-sown upland crops and vegetable crops. In terms of physiological aspect, it weighs only 30 kg and has adjustable handle height and operating angle to suit the needs of the user.

Fig 2: Field performance of battery operated single row weeder

The actual field capacity was calculated based on field observation from the speed 1.5 km/h, 1.8 km/h and 2.0 km/h with 0.3 m width of operation. The highest field capacity in case of L- type blade was due to the comparatively less time required for the operation. The lowest field capacity 0.026 ha/h at 25-30 DAS was determined in case of using of C-type blade. The interaction effect of type of blade, speed and depth of cut on field capacity was found significant. The Field capacity was affected with type of blade, speed and depth of cut of weeder. The effect of different type of blade (B_1), (B_2) and (B_3) on Field capacity of the weeder was also found to be significantly different (α= 0.05). Due to different speed S_1, S_2, and S_3 and depth of cut D_1, D_2 and D_3 with type of blade B_1, B_2 and B_3 the field capacity were observed highest (0.046 ha/h) and lowest (0.026 ha/h) with speed (S_2) depth of cut (D_2) with L- type blade (B_3), while speed (S_1), depth of cut (D_3) of C- type blade (B_1), respectively. The field capacity decreases with C- type blade (B_1) and increase field capacity with L- type blade (B_3), due to the its better mixing and pulverization during weeding and more area covered in less time.

The field efficiency was observed as 85.18% under single row battery weeder with using of L- type blade and 56.66% and 66.67% with C and J- type blade, respectively. The field efficiency at 25-30 DAS was highest in battery operated weeder with L- type blade. The effect of type of blade of weeder, speed and depth of cut blade (B×S×D) on field efficiency of the weeder was also found significantly different (α= 0.05, CD=0.349). Due to interaction between type of blade, speed and depth of cut of weeder the highest field efficiency of 84.72% was observed at L- type blade (B_3) of weeder, 1.8 km/h speed (S_2) with depth of cut (D_2) whereas, lowest field efficiency of 56.46% was found at C-type of blade (B_1) of weeder, 2.0 km/h speed (S_3) with depth of cut (D_3).

The highest weeding efficiency was observed as 90.24% under battery weeder with using of L- type blade by cutting and removing the weeds as a result. The developed battery weeder worked satisfactorily. L- type blade showed higher result as compared to the C- type and J- type blade. The effect of blade type on weeding efficiency was found to be significantly (B×S×D) different (C.D. =0.083 and α = 0.05). It was noted that the weeding efficiency increased on L-type blade at 1.8 km/h speed of weeder with depth of cut 40 mm and decreased weeding efficiency when found C- type blade at 1.5 km/h speed of weeder with depth of cut 50 mm.

The maximum plant damaged at 25-30 DAS was observed as 6.42% under treatment with J- type blade battery weeder followed by 4.46% and 3.53% with C- and L- type blades, respectively. The effect of blade speed on damage percentage was found significantly (B×S×D) different (α= 0.05). It was noted that the damage percentage increased with J- type of blade (B_2) at 1.5 km/h speed (S_1) with 50 mm depth of cut (D_3), and decreased damage percentage when the L- type blade at 1.8 km/h speed (S_2) with 40 mm depth of cut (D_2). At different speed (S) the lowest damage percentage 3.18% was observed at speed 1.8 km/h (S_2) and the highest damage percentage of about 6.21% observed at speed 1.5 km/h (S_1).

Conclusion

The performance of a battery operated single row weeder in a chickpea crop was evaluated. From all of this, it can be observed that the battery operated single row weeder that has been developed perform more efficiently than conventional weeding in terms of both time and cost. Its weeding efficiency is satisfactory and its operation is easy. The machine can effectively control 92% of weeds, and it is appropriate for use with 25 DAS of crop age between rows. Weeding with this machine reduces human drudgery, reduces labour and reduces time etc. The effective field capacity of battery-operated single-row weeder was varied from 0.026 to 0.046 ha/h at 1.5 to 2.0 km/h forward speeds at 25-30 DAS. The weeding efficiency of battery operated single row weeder with 1.5 to 2.0 km/h forward speeds, C-type, J-type and L-type blade at 30-50 mm depth of cut were varied in the range of 82.75% to 90.24%. The minimum plant and maximum plant damage was observed at a L-type and J- type blade, respectively.

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