The Pharma Innovation Journal 2022; SP-11(9): 3103-3109

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(9): 3103-3109

www.thepharmajournal.com
Received: 01-07-2022
Accepted: 06-08-2022

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Performance evaluation of flame thrower for weeding in wide row crops

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Abstract
Weed is one of the important factors in productivity loss in agricultural. It is a major problem in both conventional and organic production systems. The presence of weeds in the crop shared all the important nutrients that were required for the growth of the crop. Weed reduces crop production by 31.5% overall, with 36.5% in kharif and 22.7% in rabi. Indian farmers reduce weeds by up to 10% by using various weed management methods. The weeded was operated on nine different fields on different speeds. The data for various parameters like weeding efficiency, plant damage, gas consumption, energy consumption, theoretical field capacity, effective field capacity, field efficiency, operational time, and cost of weeding by the flame thrower are evaluated by necessary calculation. The overall performance of the flame thrower was found to be better for it. The maximum and minimum weeding efficiency for the flame thrower come in at 91.98% and 87.06%, respectively, with an average of 89.10%. The maximum plant damage percentage for flame thrower was about 7.14% and the minimum is 2.14%. The average plant damage for flame thrower was 4.67%. The gas consumption for flame thrower was around 3.12 kg/ha. Also, the speed of operation for flame weeding is ranges from 0.5 km/h to 1.18 km/h. The average energy consumption for flame thrower is about 218.56 MJ/ha. And the maximum theoretical, effective, and field efficiency for flame thrower was found to be 0.1062, 0.0929, and 91.84%, respectively, while the minimum theoretical, effective, and field efficiency for flame throwers was found to be 0.0413, 0.0450, and 87.54.

Keywords: Introduction, results and discussion, summary and conclusions, references

1. Introduction
India only makes up around 2.4% of the world's land area and 4% of its water resources, yet it must sustain about 17% of the world's people as well as 15% of its cattle. Over 54.77% of India's workforce is employed in the agriculture and related fields, which together account for roughly 17.76% of the country's GDP. India's agricultural sector is now expanding at a CAGR of 3.4 percent. Currently food grain produces on an average 296.65 million tonnes (Anonymous 2020) [3]. There are several factors which affects the crop production like climate, pest, diseases and weeds, but among all these weeds creates major impact on crop production.
In India weed is the major problem regarding the crop production. According to Gharde and Singh (2018) [12], it is estimated that reduction crop production by 31.5% and 22.7% in rabi and 36.5% in kharif seasons. About 10% of losses were attributed to weeds, according to weed scientists in India. The indirect effects of weed is found on health, biodiversity losses, nutrient depletion, grain quality, etc. that causes, the overall economic losses. A plenty of India's primary crops might have reduction in yields if weeds are allowed to grow. The losses due to weeds in major crops like cotton, maize and rice are 40 to 60%, 30 to 40% and 10 to 100%, respectively.

2. Performance evaluation
Performance evaluation of the developed flame thrower was carried taking some parameters for the experiment and design. The results were analysed using variance technique. The averages of all the parameters were used for performance evaluation.

2.1 Field Parameters
Field parameters were taken at the time of experiment. Field parameters of the mechanised controlled farm such as location of that field, area of the field, length and width of the field were considered (Table 1). Shows the experimental details of field parameters while the field

operation of developed flame weeder.

Table 1: Experimental details

Parameters	Gas consumption (kg)
	Weeding efficiency (%)
	Plant damage (%)
	Field efficiency (%)
	Cost of operation (Rs)
	Speed of operation (Km/hr)

Fig 1: Field operation of developed flame thrower

3. Determination of performance parameters

The performance parameters include plant damage, gas consumption, weeding efficiency, energy consumption and field efficiency

3.1 Gas Consumption

Gas consumption is the actual gas consumed during the operation, it depends on the operating pressure and duration of operation.

$$\text{Gas Consumption}\left(\frac{\text{kg}}{\text{h}}\right) = \frac{W_1 - W_2}{T} \ldots \quad (1)$$

Where,
W1 = Weight of tank before operation, kg
W2 = Weight of tank after operation, kg
T = Total time taken for operation, h

3.2 Plant Damage

$$P_d = \frac{A}{B} \times 100 - \quad (2)$$

Where
P_d= Plant damage (%)
A = No. of injured plants in sample plot
B = Total No. of plants in sample plot

3.3 Energy Consumption

The flame weeder was operated manually in field. The human energy utilized in flame weeding operation in the field for weeder was evaluated using following formula (Chaudhary *et al*., 2006) [11].

$$E_m = 1.96 \times N_m \times Tm \ldots \ldots \quad (3)$$

Where,
Em = Manual energy expended (MJ/ha);
Nm = Number of labours spent on farm activity;
Tm= Useful time spent by a labour on a farm activity (h/ha);
The energy consumed by combustion of LPG was calculated by following formula.

$$E_g = G_c \times C_v \ldots \quad (4)$$

Where
E_g = Fuel energy consumed (MJ/ha)
G_c = Gas consumption (kg/ha)
C_v = Calorific value of fuel (MJ/kg)
So, Total energy consumption of the machine was calculated by adding manual energy expended and fuel energy consumed which is given as follows

$$E = E_m \times E_g \ldots \quad (5)$$

Where
E = Total energy consumption (MJ/ha)
E_m= Manual energy expended (MJ/ha)
E_g = Fuel energy expended (MJ/ha)

3.4 Speed of operation

Speed is calculated by the basic formula distance by time. We use stop watch for time and the distance is fix in between the plot which is 10 m.

$$\text{Speed} = \frac{D}{T} \ldots \quad (6)$$

Where,
D = Distance (Km)
T = Time (h).

3.5 Field Efficiency

The ratio of effective field capacity and theoretical field capacity expressed in percentage is known as field efficiency. The same was calculated using following formula (IS: 7927-1975

$$\text{Field efficiency} = \frac{\text{Theoretical field capacity}}{\text{Effective field capacity}} \ldots \quad (7)$$

3.6 Theoretical Field Capacity

$$\text{Theoretical field capacity } \left(\frac{\text{ha}}{\text{h}}\right) = \frac{\text{width} \times \text{speed}}{10} \ldots\ldots\ldots (8)$$

3.7 Effective Field Capacity

$$\text{Effective field capacity } \left(\frac{\text{ha}}{\text{h}}\right) = \frac{\text{Area (ha)}}{\text{Time (h)}} \ldots \quad (9)$$

4. Result and Discussions

4.1 Performance parameters

The performance parameters include weeding efficiency, plant damage, gas consumption, energy consumption, speed of operation and field efficiency.

4.1.1 Weeding efficiency for flame thrower

Weeding efficiency is the ratio between the numbers of weeds removed by flame thrower to the number of weeds present in the unit area after operation and it is expressed in percentages. (Tajuddin, 2006) [10]. On varying the speed of operation, the effect of temperature on the weed plant varies, which in turn affects temperature-regulated to germination relative to time of exposure of flame (Hills and Van Staden, 2003) [9]. The mean of weeding efficiency 89.07±0.053 and standard deviation and coefficient of variation (%) 1.60 and 1.80 is shown in following table. 2

Table 2: The mean of weeding efficiency 89.07±0.053 and standard deviation and coefficient of variation (%) 1.60 and 1.80

Parameters	B_1	B_2	B_3	B_4	B_5	B_6	B_7	B_8	B_9
Weeding efficiency (%)	90.16	90.50	91.98	89.43	88.93	88.19	88.00	87.39	87.06
Factors		Mean		Std error		SD		CV	
		89.07		0.53		1.60		1.80	

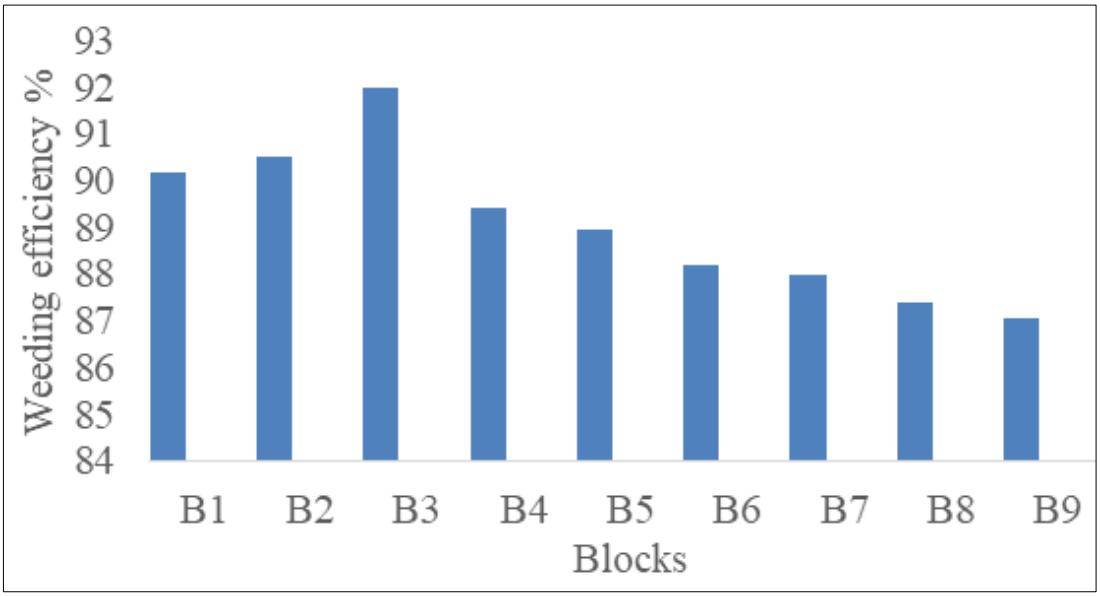

Fig 2: Weeding efficiency for flame thrower

The above graphical representation (4.1) shows the weeding efficiency by flame thrower. The maximum and minimum weeding efficiency was observed is 91.98% and 87.06% respectively, the mean weeding efficiency for flame thrower was about 89.10%. The weeding efficiency varies because of the weed did not get minimum exposure time to get damage its cell function so that the weeds can grow again in some area and it directly affects the weeding efficiency.

4.1.2 Plant damage by flame thrower

Plant damage is calculated by counting the number of injured plants in sample plot and total number of plants in sample plot. Plant damage is the ratio of number of injured plants after operating flame thrower to the number of plants present initially in the experimental plot before weeding operation. The more the number of injured plants present on the experimental plots after the weeding operations reveals more will be the plant damage. The plant damage after operating flame thrower was calculated and evaluated on the basic of basic formula. The plant damage for flame thrower for nine different blocks and the mean of plant damage (%) 4.67±0.55 and standard deviation and coefficient of variation (%) 1.67 and 34.94, respectively is shown in following table 3

Table 3: The plant damage for flame thrower for nine different blocks and the mean of plant damage (%) 4.67±0.55 and standard deviation and coefficient of variation (%) 1.67 and 34.94

Parameters	B_1	B_2	B_3	B_4	B_5	B_6	B_7	B_8	B_9
Plant damage (%)	6.14	6.66	7.14	5.20	4.33	3.57	3.42	3.01	2.57
Factors		Mean		Std error		SD		CV	
		4.67		0.55		1.67		35.94	

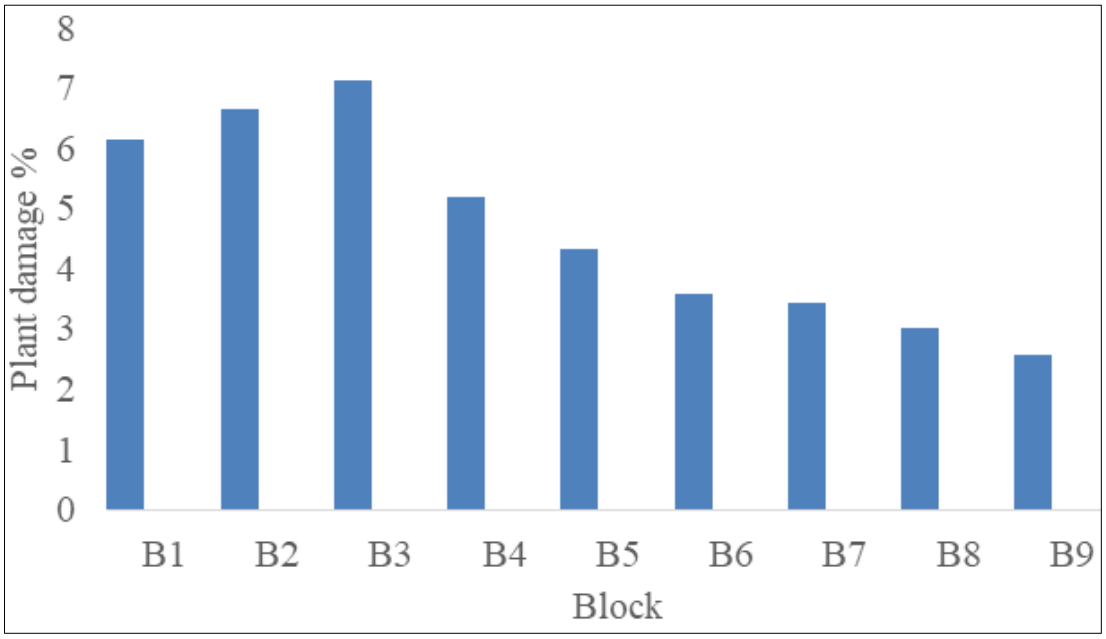

Fig 3: The damage of plants percentage by flame thrower

The above graphical representation shows the plant damage percentage. The maximum and minimum plant damage percentage was observed 7.14% and 2.57% respectively. The change in plant damage percentage is due to the increasing time of operation in that particular block which actually increase the exposure time due to this temperature of the surrounding gets increase and it affects the plants which were in contact with the flame thrower.

4.1.3 Gas consumption for flame thrower

Gas consumption is the actual gas consumed during the operation; it depends on the speed of operation. The gas consumption is equal to the ratio subtraction of the weight of gas tank before weeding operation and that of the weight of gas tank after weeding operation to the total time taken for the treatment. The less the weight of gas tank after weeding operation on the experimental plots reveals more will be the gas consumption for weeding operation. The mean of gas consumption for flame thrower is 3.12±0.08 and standard deviation for coefficient of variation % 0.25 and 8.32, respectively is shown in following table. 4

Table 4: The mean of gas consumption for flame thrower is 3.12±0.08 and standard deviation for coefficient of variation % 0.25 and 8.32

Parameters	B_1	B_2	B_3	B_4	B_5	B_6	B_7	B_8	B_9
Gas consumption (kg/ha)	3.32	3.41	3.48	3.28	3.10	2.99	2.91	2.83	2.78
Factors		Mean		Std error		SD		CV	
		3.12		0.08		0.25		8.32	

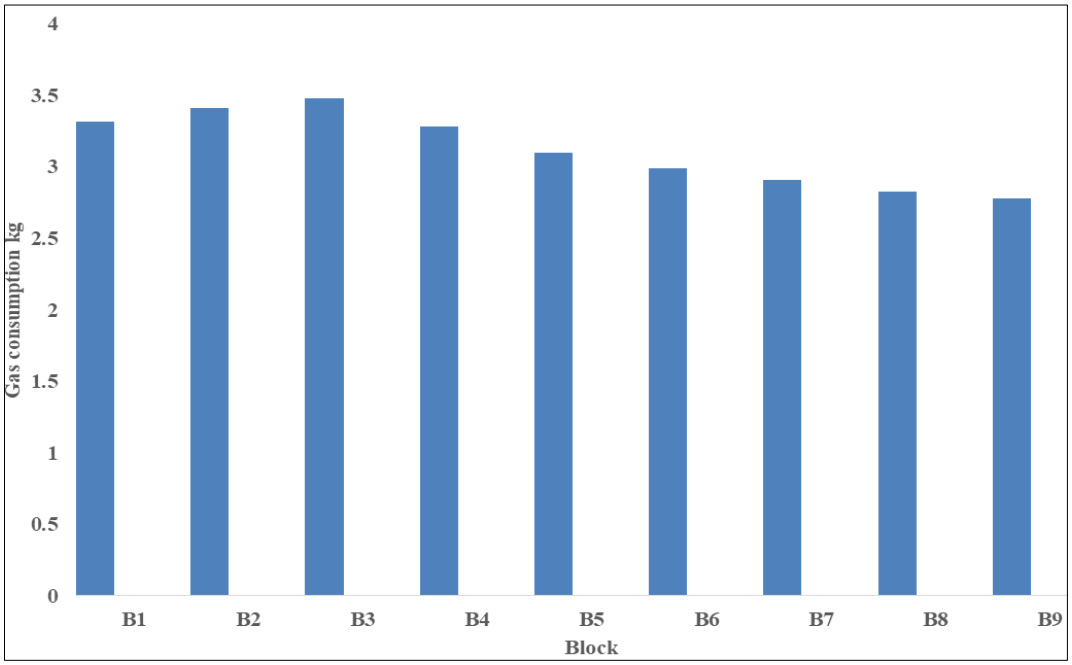

Fig 4: The gas consumption kg/ha for flame thrower

The above graphical representation shows the gas consumption kg per ha. The maximum and minimum gas consumption for flame thrower for weeding operation was found 3.48 kg/ha and 2.78 kg/ha respectively. On varying the speed of operation, the operational time per unit area varies, which in turn affects the gas consumption, similarly the gas consumption is totally depending upon the speed. The less the weight of supply tank after operation gets more gas consumption for the operation.

4.1.4 Speed of operation for flame thrower

The speed of flame thrower was calculated and evaluated on the basis of formula, for measurement of time we used stop watch and for distance is fixed. The mean of gas consumption for flame thrower is 0.77±0.074 and standard deviation and coefficient of variation (%) 0.22 and 28.91, respectively is shown in following table 5

Table 5: The mean of gas consumption for flame thrower is 0.77±0.074 and standard deviation and coefficient of variation (%) 0.22 and 28.91

Parameter	B_1	B_2	B_3	B_4	B_5	B_6	B_7	B_8	B_9
Speed of operation (km/h)	0.60	0.56	0.50	0.66	0.73	0.88	0.90	0.99	1.18
Factors		Mean		Std error		SD		CV	
		0.77		0.074		0.22		28.91	

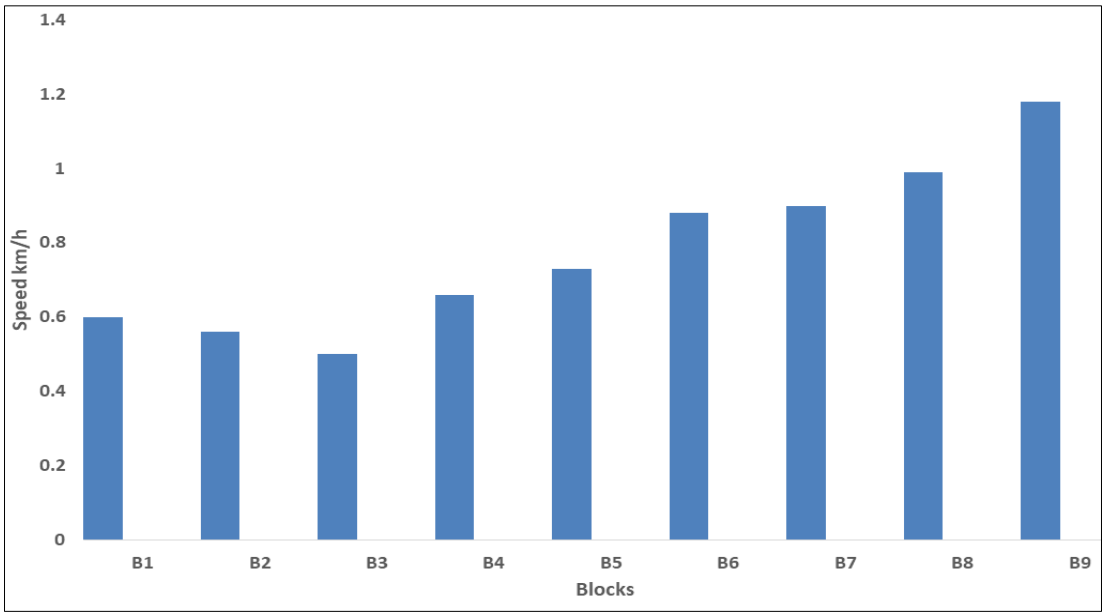

Fig 5: The speed of operation for flame thrower

The graphical representation (4.4) of speed for operation of flame thrower shows in the fig 5. The maximum and minimum speed for operation for flame thrower was 1.18 km/h and 0.5 km/h respectively.

4.1.5 Energy Consumption for flame thrower

The flame thrower is operated manually in field. The human energy utilized in flame weeding operation in the field for weeder is evaluated. Manual energy expended or energy consumption is equal to the product of number of labours used in the operation and total operating time taken by operator with coefficient of human energy consumption and the fuel energy consumed by the flame thrower combines energy consumption of the flame thrower, here we did not consider the machine energy which is very minimum. The mean of energy consumption for flame thrower is 214.53±10.09 and standard deviation and coefficient of variation (%) 30.27 and 14.11, respectively.

4.1.6 Theoretical field capacity and effective field capacity

The rate of coverage of the flame thrower based on 100% of time at rated speed and covering 100% of its rated width is known as theoretical field capacity. The effective field capacity of the weeder is calculated on the basis of the actual area covered by the weeder. Values of theoretical field capacity with respect to different speeds of operation and the effective field capacity and the mean for theoretical and effective field capacity for flame thrower is 0.069±0.0067 and 0.062±0.005, respectively. The standard deviation and coefficient of variation (%) for theoretical and effective field capacity 0.020, 29.52 and 0.0170, 27.48, respectively which is shown in following table 6.

Table 6: The standard deviation and coefficient of variation (%) for theoretical and effective field capacity 0.020, 29.52 and 0.0170, 27.48

Parameter	B_1	B_2	B_3	B_4	B_5	B_6	B_7	B_8	B_9
Theoretical field capacity(ha/h)	0.054	0.050	0.045	0.054	0.065	0.074	0.081	0.089	0.106
Factors		Mean		Std error		SD		CV	
		0.069		0.0067		0.0203		29.528	
Parameter	B_1	B_2	B_3	B_4	B_5	B_6	B_7	B_8	B_9
Effective field capacity(ha/h)	0.048	0.046	0.041	0.053	0.058	0.066	0.074	0.078	0.092
Factors		Mean		Std error		SD		CV	
		0.0621		0.0056		0.0170		27.487	

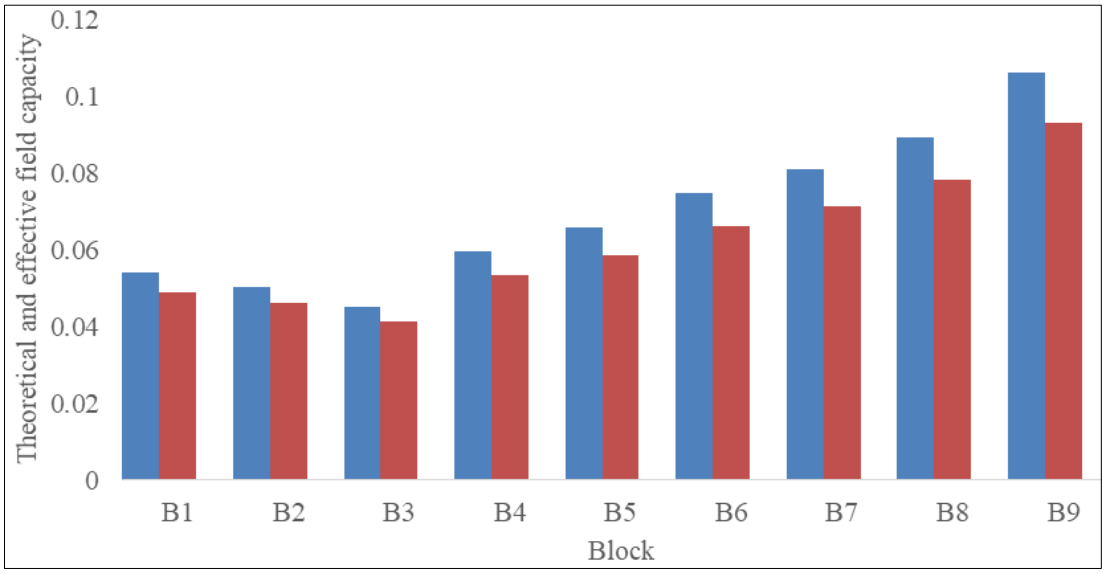

Fig 6: The theoretical and effective field capacity of flame thrower

The above graphical representation (6) shows the theoretical field capacity and effective field capacity for the particular blocks. The maximum and minimum theoretical and effective field capacity was observed 0.10, 0.045 and 0.092, 0.041 respectively.

4.1.7 Field efficiency for flame thrower

The ratio of effective field capacity and theoretical field capacity expressed in percentage is known as field efficiency. The mean of field efficiency for flame thrower is 89.42±0.51 and standard deviation and coefficient of variation (%) 1.54 and 1.72, respectively is shown in table 7.

Table 7: The mean of field efficiency for flame thrower is 89.42±0.51 and standard deviation and coefficient of variation (%) 1.54 and 1.72

Parameters	B_1	B_2	B_3	B_4	B_5	B_6	B_7	B_8	B_9
Field efficiency (%)	90.43	91.48	91.84	89.63	89.04	88.77	88.20	87.89	87.54
Factors		Mean		Std error		SD		CV	
		89.42		0.51		1.54		1.72	

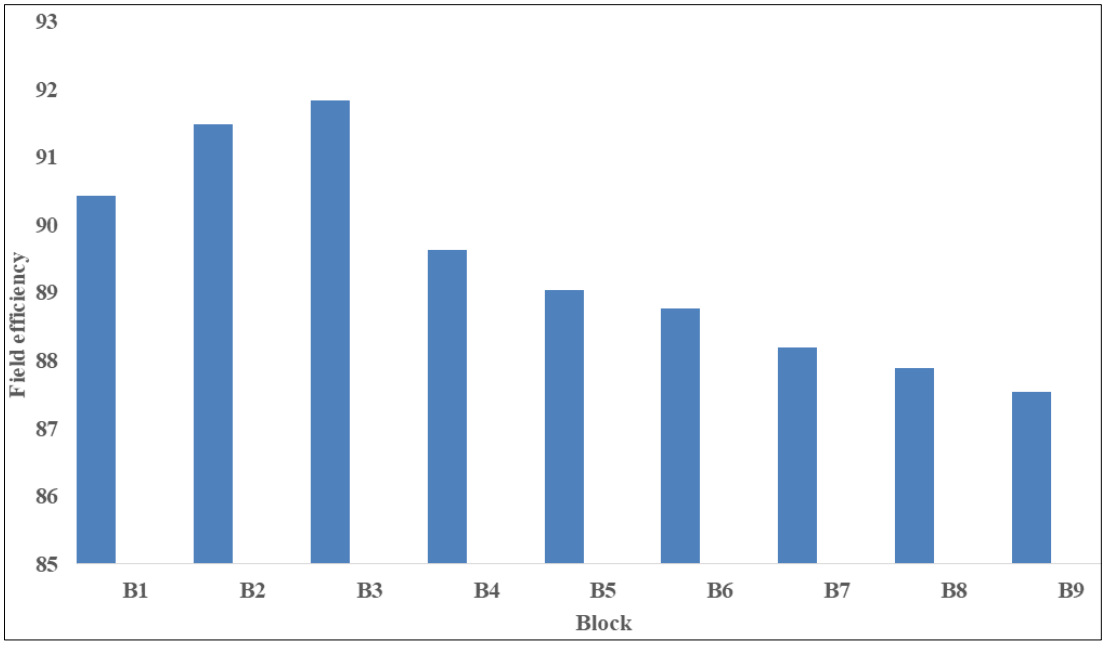

Fig 7: Field efficiency for flame thrower

5. Conclusion

1. The dimensions of the developed flame thrower were adequate for better working and efficient operation.
2. The maximum and minimum weeding efficiency for flame thrower was found 91.98% and 87.06%, respectively, and the average weeding efficiency was 89.10%.
3. The maximum and minimum plant damage percentage for flame thrower was observed 7.14% and 2.57%, respectively. The average plant damage percentage for flame thrower was 4.67%. It was because of the high temperature in that block due to the higher exposure time of flaming.
4. Gas consumption was observed at a maximum of 3.14

kg/ha and a minimum of about 2.78 kg/ha. The average gas consumption for flame thrower was observed at 3.12 kg/ha.

5. The maximum and minimum speeds of the operation for flame thrower was about 1.18 km/h and 0.5 km/h, respectively, while the average time for covering one heater of land is 16.18 ha/h.
6. The maximum and minimum theoretical field capacity and effective field capacity were observed to be 0.1062, 0.0450 and 0.0920, 0.0413, respectively.
7. The maximum and minimum field efficiency for flame thrower was observed 91.84% and 87.54% respectively.
8. Energy consumption was observed at a maximum of 260.12 MJ/ha and a minimum energy consumption of 172.16 MJ/ha and average energy consumption for flame thrower was observed 218.56 MJ/ha.
9. The flame thrower was compared to hand weeding. The maximum value of weeding efficiency is 99.95% for hand weeding, whereas it is 89.10% for flame weeding. Hand weeding is 10.85% more efficient than flame weeding.
10. The maximum value of operational time is 240 man-h/ha for hand weeding, whereas the minimum value of operational time is 16.18 man-h/ha for flame weeding. The operational time of flame weeding is 93.25% less than that of hand weeding.
11. The maximum value of energy consumption is 376.8 MJ/ha for hand weeding, whereas the minimum value of energy consumption is 189.59 MJ/ha for flame weeding. The energy consumption of flame weeding is 41.99% less than hand weeding.

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