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A review on development and evaluation of intercultural implements for small and marginal farmers

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Abstract
The removal of weeds grow in-between crops is an important operation in crop cultivation as they reduce the crop growth and yield and review indicated that the highest 99.44% weeding efficiency for Khurpi followed by grubber weeder (96.8%) but latter one is a viable option with more field capacity than Khurpi and weeding efficiency of 82.89%, 79.59% and 97.21% recorded with power weeder, wheel hoe and traditional method respectively. A manually operated sprocket weeder showed that, the weeding efficiency of the sprocket weeder was found to be 94.5% with a field capacity of 0.032 ha/h with a time saving of 84 per cent and cost of operation Rs. 375/ha with a cost saving of 79.16 per cent compared to traditional method. A manual operated single row weeder for groundnut crop with field capacity of 0.0285 ha/h with higher weeding efficiency (80.42%) which is less compared to sprocket weeder but more suitable for groundnut crop. The Mono wheel operated sprayer cum weeder developed, with an actual field capacity of 0.031 ha/h, a theoretical field capacity of 0.0428 ha/h, a field efficiency of 65.54 percent was observed. The Modified Push and pull type cycle weeder was superior when compared with twin wheel hoe and Khurpi, with 83.65% of weeding efficiency, field capacity of 0.035 ha/) and benefit cost ratio of 2.156.TNAU weeder showed the increase in the weeding efficiency (5%), field capacity (21%) and performance index (7%) as compared to straight and V blade weeders (4, 21 and 6 percent), respectively.

Keywords: Intercultural operations, weeding tools, manual weeding, weeding efficiency, field capacity

Introduction

Agriculture and allied sectors, are the largest source of livelihood in India. 70 percent of its rural households still depend primarily on agriculture for their livelihood and 82 percent farmers are being small and marginal (FAO 2018). Agricultural mechanization involves the use of tools, implements and machines to improve time and labour efficiency that has historically been neglected within the context of developing countries for a long time. Factors that reduce the availability of agricultural energy compromise the ability to grow enough land and have long been recognized as a source of poverty. Mechanization promotes economic growth through higher yields and expansion of the cultivated area, either by introducing new lands or multiple cropping in the same area (Negrete, 2018) [10].

The agriculture operations performed in the field after sowing but before harvesting of crop are termed as intercultural operations which is described as breaking clods inthe surface soil, uprooting weeds (unwanted plants), enhancing soil aeration, thereby promoting the activities of microorganism besides making good mulch, to conserve soil. These operations are accomplished by many tools and implements, such as hoes, rotary offset tillers, offset harrows, cultivators, rotary hoes etc. (Namdev *et al*., 2019) [9]. Most of the farmers use age-old implements and their operation causes a lot of drudgery and is time consuming apart from inefficient loosening of soil and uprooting of shallow rooted weeds. Currently the availability of the animal powers has reduce due to reduction in animal population and emphasized for farm mechanization centering small and marginal farmers in the country. The precision in farm mechanization is very important to increase quality production. Due to fragmentation of land, the holdings of farmer reduced to small farms, it is very difficult to use of machineries for intercultural operations. Hence, for small and marginal holdings self- propelled machine and many other small implements were used for the purpose (Karale & Khambalkar, 2008) [4].

In India currently, weeds are predominantly being managed specially through manual and chemical techniques. Mechanical weeding is usually more economical than manual method. These implements rely on burying and uprooting weeds grown between crop rows which are wide enough to facilitate movement of the implements without significant injury to crops. Therefore, this method is applicable only in those crops sown in straight rows and having suitable row widths. (Shad, 2015) [12]. Therefore, in order to overcome this difficulty, we need to review the existing intercultural implements developed by researchers to recommend small and marginal farmers for performing efficient intercultural operations, and also we can look forward to developing more efficient and economical intercultural implements for field operations.

Materials and Methods

Considering the constraints and problems faced by the small and marginal farmers on weeding, intercultural operations and decreased crop yield in dryland conditions, the development of intercultural implements is important for enhancing crop yield besides timely operation and reduction in drudgery. Hence, an attempt was made to review the research articles on different intercultural tools and implements developed by the different researchers and scientists in different regions of the country are collected and analysed the situations regarding their uses under different situations in dryland conditions are presented in this review paper.

Results and Discussion

Intercultural Implements

Hand tools

Hand weeding is a common method of weed control on vegetable farms, especially in developing countries. It requires considerable physical labour and is a significant economic burden, yet comparative studies on hand weeding tools are rare (Tiwari *et al*., 2021) [16]. Small weeding tools are traditional hand held type hoes like "Khurpi" (Fig.1) used by the farmers. These tools are operated in squatting posture and have low work output. Different designs of these tools are being used by the farmers of different regions. These tools are suitable for removing the weeds between plants in both row-sown and broadcast fields.

The field experiment on "performance evaluation of different weeding tools in maize" by (Shekhar *et al.*, 2010) [13], indicated that grubber weeder (Fig.2) had a higher field capacity (0.008 ha/hr) than 'Khurpi' (0.002 ha/hr).The higher weeding efficiency (99.44%) was recorded in treatment 'Khurpi' followed by grubber (96.8%). The plant damage observed greater with grubber (0.76%) followed by 'Khurpi' (0.46%). The cost of operation of 'Khurpi' was higher (Rs. 4051/ha) than grubber (Rs. 1158/ha). The study concluded that, field efficiency of grubber was higher than 'Khurpi'. In spite of results, we need to look into the type of crop grown, land holding and economical aspects of the farmer.

Fig 1: Khurpi

Fig 2: Grubber weeder

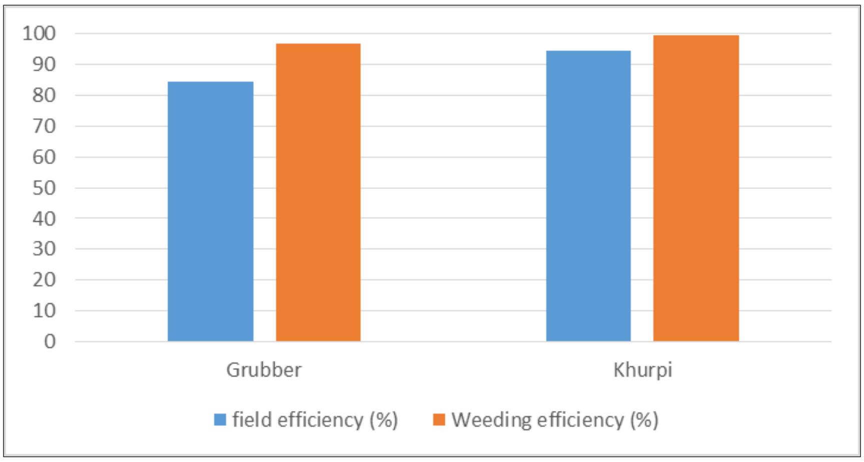

Fig 3: Field efficiency and weeding efficiency of weeding tools (%)

The most common weeding tool is a traditional hand tool (Powrah) shown in Fig. 4 used to cultivate very small areas. A wide, thin cutting blade is affixed to the handle. Powrah weighs 1.5 kg, has a front cutting edge having a width of 220 mm, and a blade length of 250 mm (Rumandla Sandeep Kumar *et al*., 2017) [11]. Power weeder has been evaluated for its field performance in comparison with wheel hoe and traditional hand tool (powrah) taking into consideration their cost of operation in the farmers fields. Besides uprooting weeds, the removal of uprooted weeds will take more time and labour, hence a multipurpose weed rake was developed at the workshop of College of Agricultural Engineering, Bapatla. Field efficiency of power weeder, wheel hoe and powrah were 81.36%, 61.88% and 89% respectively. The power weeder had the lowest weeding time 20.24 h/ha, maximum coverage area 0.049 ha/h, over wheel hoe and traditional method. The weeding efficiency of power weeder, wheel hoe and traditional method reported 82.89%, 79.59%and 97.21%, respectively, with the cost of operation of Rs. 1676/ha, Rs 889/ha and Rs 3990/ha (Rumandla Sandeep Kumar *et al*., 2017) [11].

Cost of operation of developing weed rake was lower than traditional methods. A multi crop weed rake was developed by Rumandla Sandeep Kumar *et al*., (2017) [11] to meet the needs of small farmers, Weed rake (Fig. 5) consists of following components;

- Tool bar (frame),
- Fingers,
- Ferrule and
- Handle.

Table 1: Parameters of Weed Rake

Details	Weed Rake
Working width, mm	450
Weight, kg	1.82
Height of handle from ground level, mm	800-1000
Cost, Rs	300

(Rumandla Sandeep Kumar *et al*., 2017) [11]

Fig 4: Traditional hand tool (powrah)

Fig 5: Weed Rake

The Functional and Economical Aspects of Weed Rake

- Extent of achieving timeliness of operation
- Improvement in quality of work.
- Reduction in drudgery
- Improvement in safety
- Cost effectiveness

Manually operated intercultural implements

A manually operated sprocket weeder and evaluated for its performance. Various parameters such as weeding efficiency, plant damage, field capacity, draft and power input of the weeder were studied. The sprocket weeder was developed by using inexpensive bicycle components. The major parts of the weeder consisted of the front portion of a bicycle namely handle bar, front axle, sprocket, wheel hub, fork and galvanized iron pipe. V-shaped blade made from hardened steel was attached to the fork with the help of U-clamp which is adjustable (Manjunatha *et al*., 2014) [8]. The results showed that, the weeding efficiency of the sprocket weeder was found to be 94.5% with a field capacity of 0.032 ha/h with a time saving of 84 per cent. The cost of operation was found to be Rs. 375/ha with a saving of 79.16 per cent compared to traditional method. It was also observed that, there was no plant damage while carrying out the weeding operation with the sprocket weeder.

Table 2: Field performance of the manually operated sprocket weeder

Sr. No.	Description	Traditional method (Khurpi)	Sprocket weeder
1	Weeding efficiency, %	96	94.5
2	Plant damage, %	0.67	Nil
3	Effective working width, cm	15	30
4	Average working depth, cm	2.5	4.0
5	Draft requirement, kg	--	30.0
6	Effective field capacity, ha/h	0.005	0.032
7	Cost of operation, Rs/h	9	12
8	Cost of operation, Rs/ha	1800	375
9	Saving in cost when compared to treatment T1 (%)	---	79.16
10	Saving in time when compared to treatment T1, (%)	---	84.00

Manjunatha *et al*., 2014 [8]

The specifications of manually operated sprocket weeder designed by (Manjunatha *et al*., 2014) [8] was given below

Table 3: Specifications of manually operated sprocket weeder

Table A : Specifications of manually operated sprocket weeder		
Sr. No.	**Parameters**	**Description**
1	Overall dimensions, mm	
	Length	1400
	Width	570
	Height	930
2	Weight, kg	4.5
3	Diameter of bicycle sprocket, mm	180
4	Diameter of wheel hub, mm	30
5	Length of G.I pipe, mm	800
6	Length of bicycle fork, mm	550

Fig 6: The weeding operation by sprocket weeder

An experiment conducted on "-the performance evaluation of manual operated single row weeder for groundnut crop implemented" to evaluate the field performance of developed manual operated weeder was carried out at Department of Farm Machinery and Power of College of Agricultural Engineering and Technology, Junagndh. Test result indicates a clear view for adopting this design of manually operated row crop weeder because it is easy to operate and outcome of weeding efficiency is also satisfactory. The developed weeder can work up to 4.0 cm depth of operation with field capacity of 0.0285 ha/h. higher weeding efficiency was obtained (i.e. up to 80.42%) The performance index of the developed weeder was obtained 1210.53 (Bhavin *et al*., 2016) [2].

Table 4: Speed of travel and Weeding efficiency of manual operated weeder

Trail	Distance covered (m)	Time taken (min)	Traveling speed (m/min)	Average (m/min)	Area (m^2)	Weed density before inter-cultivation (W1)	Weed density after inter-cultivation (W2)	Weeding efficiency (%)	Average (%)
1	150	5.94	25.25	25.17	0.9	60	12	80	80.42
2		6.02	24.91			93	17	81.72	
3		5.98	25.08			75	13	82.66	
4		5.91	25.30			120	26	78.32	
5		5.92	25.33			102	21	79.45	

The constructional details, design and fabrication of different component of row crop weeder. The elevation and plan of the developed weeder is shown in Fig. 7. The constructional details and main components of the weeder are ground wheel, ground wheel shaft, blade, prong, main frame and handle have been explained below as expressed by Bhavin *et al*., (2016) [2]

Ground wheel: There are two ground wheels. They are fabricated from mild steel bar of 12 mm diameter. The diameter of each ground wheel was kept 250 mm. The spokes are provided in the wheels for attaching the hub of 35 mm diameter with the help of washers with inner diameter of 35 mm and outer diameter of 95 mm.

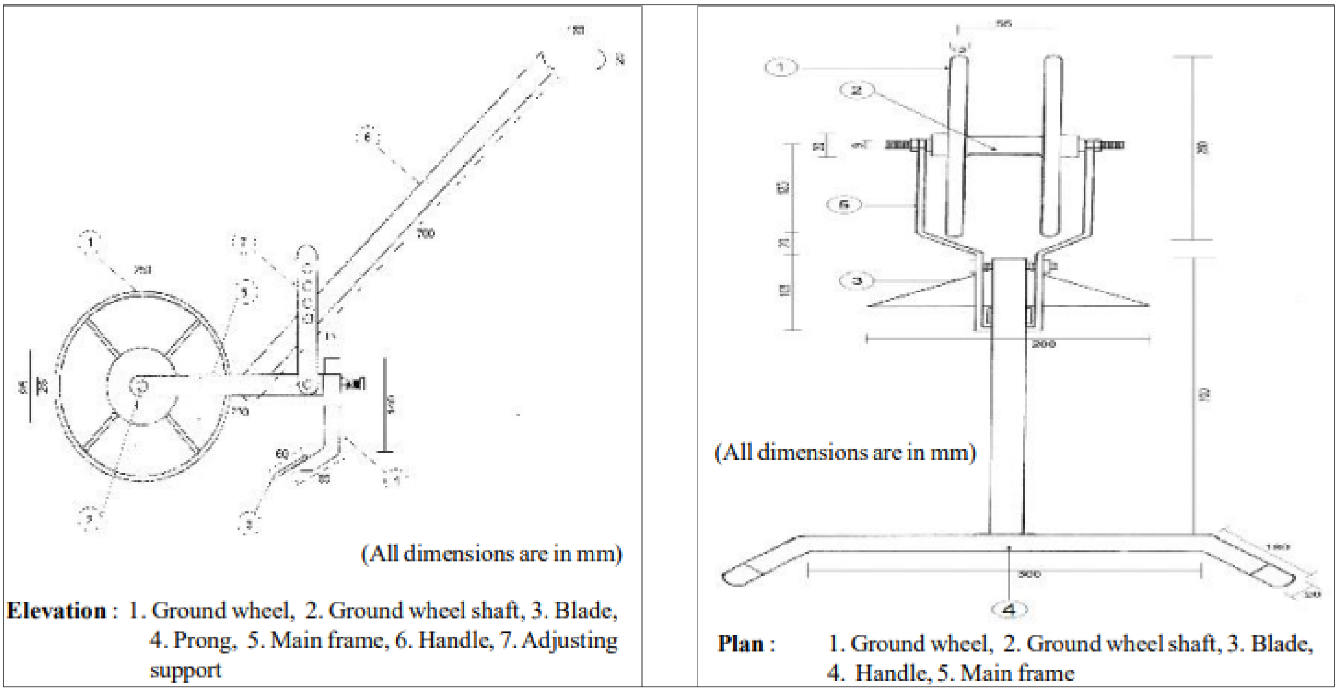

Fig 7: Plan of the developed weeder

Shaft: It is made of mild steel bar of 9 mm diameter and 160 mm length. The threads are provided on both the ends to fixthe main frame.

Blade: It is made of cast iron. It is V-shape with angle of 1250. It serves two purposes first to minimize the root damage and second provide sliding action so root may not stick to the blade. The width and length of the blade are 60 mm and 200 mm, respectively. The complete assembly of the cutting blade is shown in Fig. 7. It is designed to work in the soil under the interaction of different soil forces. Therefore the metal selected is strong enough to sustain the prevailing forces, as well as to support the load of the implement. The blade is sharpen at the lower end so it can penetrate into the soil at proper angle and desired depth during weeding. The blade is attached to the prong at an angle of 1400.

Prong: It is made of mild steel square bar and size of the bar is 200 × 15 × 15 mm. The blade is fixed at the one end of the prong and on the other end marks are provided at 10 mm, 25 mm, 40 mm and 55 mm from the top of the prong on back side to fix the nut so that desired depth can be obtain.

Main frame: It is fabricated from two mild steel flat of 250 × 25 × 5 mm. It is bent in such a way that the outer ends of frame are kept at 110 mm and inner ends are kept at 35 mm. At outer end main shaft is bolted and at inner end provision of handle and adjusting support is made.

Handle: It is most important part of the weeder. It is fabricated from the galvanized iron pipe of 700 mm length and 20 mm outer diameter. It is bent from both the sides with 180 mm at an angle of 400. The desired height of the handle from the ground surface is obtained with the adjusting support. The handle is joined to the main frame with the help of handle pipe. Rubber grips are provided at both the ends of pipe for comfort handling. Development these type of weeder for row crop and assessment functional suitability and weeding efficiency, to increase the productivity per unit area of small land holdings of farmers and considering their economic condition.

A hand pushed weeder developed and evaluated by Attanda *et al*., (2013) [1]. The field performance was compared with traditional hand-held hoe on a variety of TZPB-SR maize crop. The means of forward speed, actual field capacity and weeding efficiency was 0.092 m/s,0.028 ha/hr and 75.17% respectively compared to manual hoe (0.013 m/s, 0.0059 ha/hr and 77.98% respectively).The weed covers a single row and the main advantages are:

- The developed mechanical weeder can be done locally in any metal workshop.
- The developed hand-pushed weeder has higher forward speed and effective actual field capacity which is more than that of the traditional hand-held hoe.
- This evaluation shows, it is very effective under rainy season

In the Agricultural college farm, Bapatla during the year 2012-13 evaluated star weeder and wheel hoe of intercultural implements (Fig. 8) under dry land situation. Actual field capacity, theoretical field capacity, field efficiency, weeding efficiency, plant damage and cost of operation were considered for evaluation (Kiran *et al*., 2014) [5].

Table 5: Technical specification of weeders

	Star weeder	Wheel hoe
Parameters		
Technical specifications (cm)		
Total length	138	169
Wheel width	6	4
Cutting width	17.5	20.5
Wheel diameter	16	32
Speed of operation (kmph)	1.5	1.41

(Kiran *et al*., 2014) [5]

Fig 8: Star weeder and Wheel hoe

Actual field capacities and theoretical field capacities of wheel hoe and star weeder were 0.022 ha/h, 0.021 ha/h and 0.030 ha/h, 0.026 ha/h respectively. Star weeder (80.76%) has higher field efficiency than wheel hoe (73.66%). Plant damage observed for wheel hoe and star weeder were 2.20%, and 1.17% respectively. Star weeder (75.4%) has more weeding efficiency than other wheel hoe (74.0%). Cost of operation of wheel hoe and star weeder was Rs.1696.5/ha and Rs.1785.37/ha respectively.

Table 6: Field parameters observed in dry land (Maize crop) with weeders.

Type of weeder	Theoretical field capacity (ha/h)	Actual Field capacity (ha/h)	Field Efficiency (%)	Weeding Efficiency (%)	Plant damage (%)	Cost of operation (Rs/ha)
Star weeder	0.026	0.0210	80.76	75.4	1.17	1785.37
Wheel hoe	0.030	0.0221	73.66	74.0	2.20	1696.50

(Kiran *et al*., 2014) [5]

There is need for development of effective weeding machine for increasing the productivity. In order to overcome these difficulties, Singh *et al*., (2020) [15] proposed a wheel driven weeder, suitable device and run without fuel, which is easy to move the wheel as well as also remove weeds through weeder blade. The constructional details and specification of mono wheel operated sprayer cum weeder are given below.

Table 7: Specification sheet of mono wheel operated sprayer cum weeder

S. No	Name of implement	Wheel operated weeder
1	Type of Weeder.	Manually operated
2	Type of sprayer	Wheel operated
3	Crop for Which suitable.	Chickpea, mustard, wheat, safflower.
	Overall dimension in mm	
4	Length	1677
5	Width	900
6	Height	1394
7	Weight in kg	35kg
	Detail of weeding component	
8	Type:	Straight blade
9	Dimension	25*10*1.5
10	Working width	25
11	Material of construction:	Mild steel
	Detail of frame weeder	
12	Construction	Adjustable type
13	Dimension of major members:	1200*260*30
	i) Mono wheel (cycles wheel)	
14	Diameter, cm	50
15	Width, cm	5
16	Material	Stainless steel
	ii) Detail of ground wheel	
17	Diameter, cm	18
18	Width, cm	2
19	Material,	Mild steel
	Detail of handle	
20	Construction	Adjustment
21	Height of handle from ground level, cm	0-66.8 to 0-96.8
22	Details of adjustment	Adjustment through nut and bolt
23	Ground clearance	36.4(ground surface to main frame)
24	Details of transporting system	Mono wheel as well as ground wheel

This weeder can also be used for other line sown hill land crops and vegetables, as row spacing can be adjusted. As far as design is concern, it is light in weight about 20 kg and its handle height and angle of operation can be adjusted as per operator requirement.

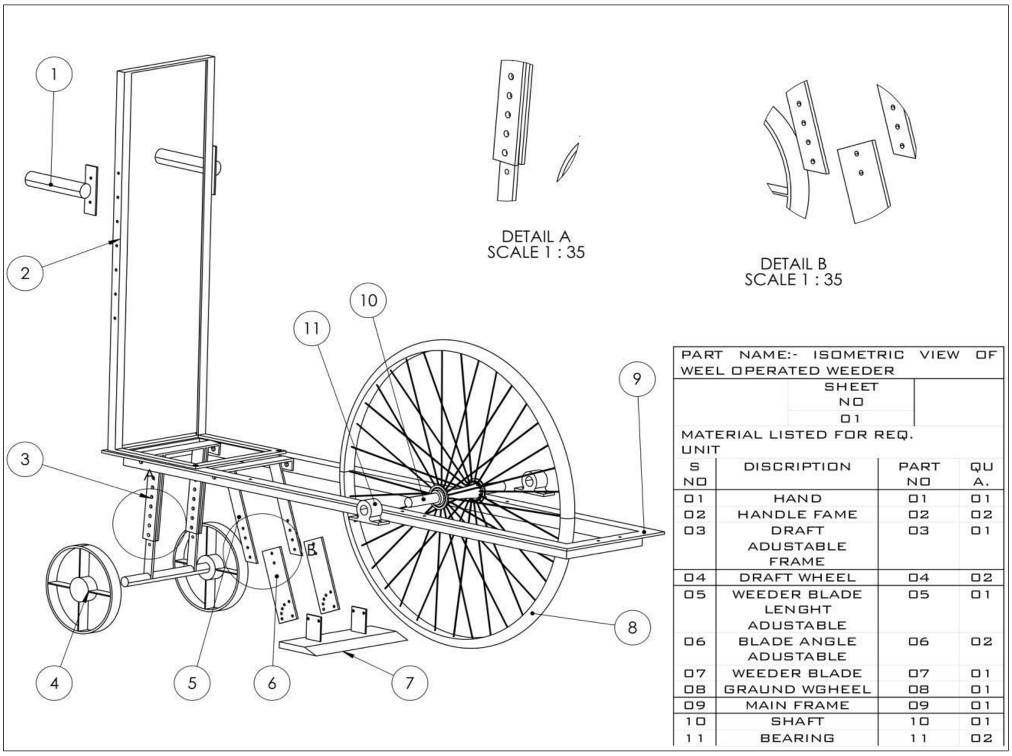

Fig 9: Mono wheel operated sprayer cum weeder

In Chhattisgarh, India, an experiment by Singh *et al*., (2020) [15], examine the field performance of a newly constructed manually operated weeder. During the test in chickpea crop, many characteristics such as field capacity, weeding efficiency, and weeder performance index were measured. The developed weeder machine can work at a depth of 3.0-4.0 cm, with an actual field capacity of 0.031 ha/h, a theoretical field capacity of 0.0428 ha/h, a field efficiency of 65.54 percent. The plant injury was found 2.166 and weeding efficiency was 88.15 percent, with a performance index of 12622.1. Experiments also proved that the developed wheel operated weeder require significantly lesser time for weeding than hand weeding. It was simple to use and, required less human effort to operate. The speed at which a mono wheel-operated sprayer, the test was carried out by choosing a distance of 10 m and recording the time required to travel that distance. The average speed of travel was computed using the data collected from the experiment and the average speed was found at 28.2 meters per minute.

Table 8: Speed of travel and Field capacity of mono wheel operated sprayer cum weeder

Trails	Distance (m)	Time (min.)	Speed (m/min.)	Average speed (m/min.)	Area covered (m2)	Time to cover the area (min)	Field capacity (ha/h)	Average F.C. (ha/h)
1	10	0.36	27.8	28.2	100	20.8	0.031	0.031
2		0.5	33.4			20.7	0.032	
3		0.43	23.3			21.21	0.03	

Singh *et al*., 2020 [15]

An experiment was performed by Kumar *et al*., (2018) [6], to assess the field performance of various weeders, including the Khurpi, twine wheel hoe, push pull type cycle weeder, and a modified push pull type cycle weeder. The studies were conducted in a farmer's field by KVK, Sabour experimental plots on HD-2967 wheat variety in an area of 4 hectare. Various factors such as weed control, field capacity (ha/h), weed population/m^2 (before and after interculturing), yield (q/ha), cultivation cost (Rs/ha), gross return (Rs/ha), net return (Rs/ha), and B:C ratio were recorded. The field capacity of 0.002, 0.010, 0.020 and 0.035 ha/hr respectively observed for Khurpi, twine wheel hoe, push pull type cycle weeder, and a modified push pull type cycle weeder. The maximum net return was found for refined cycle wheel weeder as Rs.36,394.50/ha, while minimum was recorded for Khurpi as Rs. 24,683/ha. The maximum weeding efficiency was observed with 'push pull type cycle weeder certain refinements' (83.65%) followed by 'Khurpi' (81.87%), and by 'twine wheel hoe' (79.02%) and 'push pull type cycle weeder' (78.89%). Earlier Shekhar *et al*., (2010) [13] has reported higher weeding efficiency withKhurpi than other weeder. Now, the modified version of cycle wheel hoe has shown more weeding efficiency than Khurpi. The maximum weeding efficiency with ' modified version of cycle wheel hoe' was observed because of the capability of this tool to do more work because of three small furrows. However, push type cycle weeder and its modified version cannot be used for closer spacings, in that case Khurpi is more suitable as its weeding efficiency is also much closer to the weeder, which is showing highest weeding efficiency. Weeding using mechanical devices reduces labour costs and saves time. Farmers' use Khurpi as a weeding tool is much inferior to the refined push pull type cycle weeder. While it performs similarly to a push-pull cycle weeder, it has several advantages in terms of effective field capacity, yield, and benefit-to-cost ratio (Kumar *et al*., 2018) [6].

Table 9: Performance evaluation of weeders

Treatments	Weed density before intercultivation	Weed density after intercultivation	Weeding efficiency	Field capacity (ha/h)	Net return (Rs./ha)	BCR
Khurpi	44.15	8	81.88	0.002	24,683	1.655
Twin wheel hoe	46	9.65	79.02	0.01	31,377	1.95
Push and pull type cycle weeder	45.25	9.55	78.90	0.002	34,700	2.075
Modified Push and pull type cycle weeder	46.8	7.65	83.65	0.035	36,394	2.156

P. Kumar *et al*., 2018 [6]

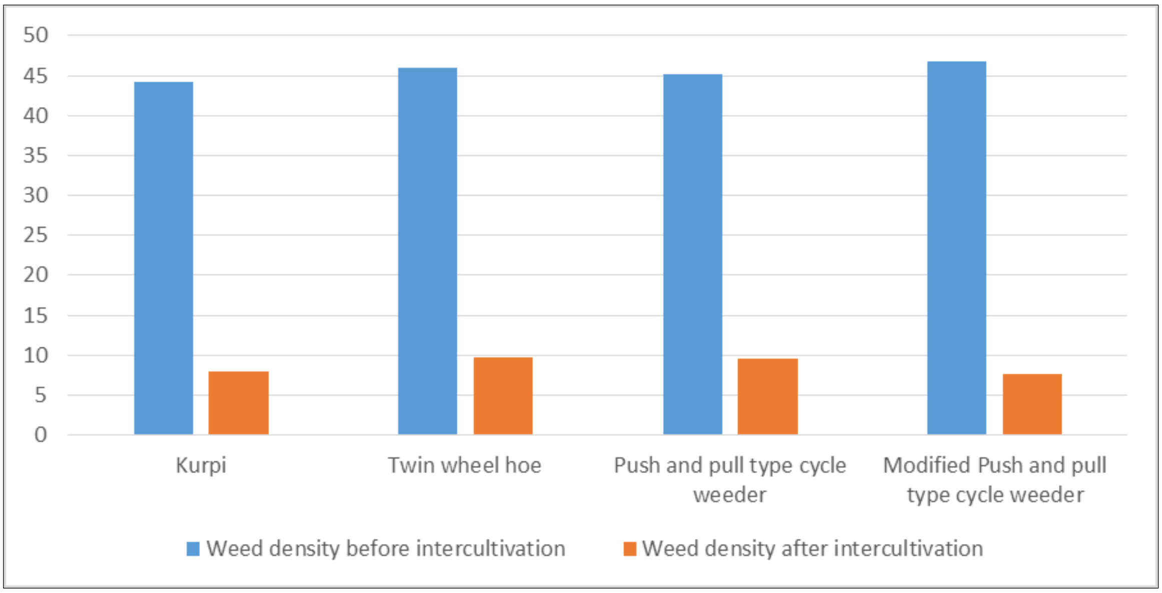

Fig 10: Weed density before and after intercultural operation

Fig 11: A. Khurpi B. Twin wheel hoe

Fig 12: (A) Push and pull type cycle weeder (B) Modified Push and pull type cycle weeder.

Manually operated weeders are push/pull weeders that are operated by applying force in a dynamic motion. However, existing dryland weeders are based on static force exertion, despite the fact that they are dynamic in nature and require a greater amount of force than static ones. As a result, dryland weeders with straight blades (apex angle 1800) and V blades (apex angle 900) were designed based on dynamic strength optimization in the laboratory. The ergonomics and field performance of designed weeders as well as one existing twin wheel hoe were evaluated. With minimal effort, the designed weeders improved field performance in terms of field capacity, weeding efficiency, and performance index. It was noticed that, the developed weeders showed an increased performance in terms of field capacity, weeding efficiency and performance index with minimum physiological responses over twin wheel hoe. The field evaluation of the weeders was conducted in cotton crop at TNAU, Coimbatore. Later, based on the performance of the operators during weeding operation, the ergonomic parameters were drawn (Chethan *et al.*, 2018) [3].

Table 10: Field performance results of the twin wheel hoe, straight blade and V blade weeders

Parameter	Twin wheel hoe	Developed weeders	
		Straight blade	V blade
Weeding efficiency (%)	92.5	97.8	96.3
Draft force (kg force)	17.75	22.24	22.13
Power requirement (hp)	0.087	0.108	0.107
Field Capacity (ha-h-1)	0.027	0.034	0.034
Performance index (%)	2838	3052	3018

Chethan *et al.*, 2018 [3]

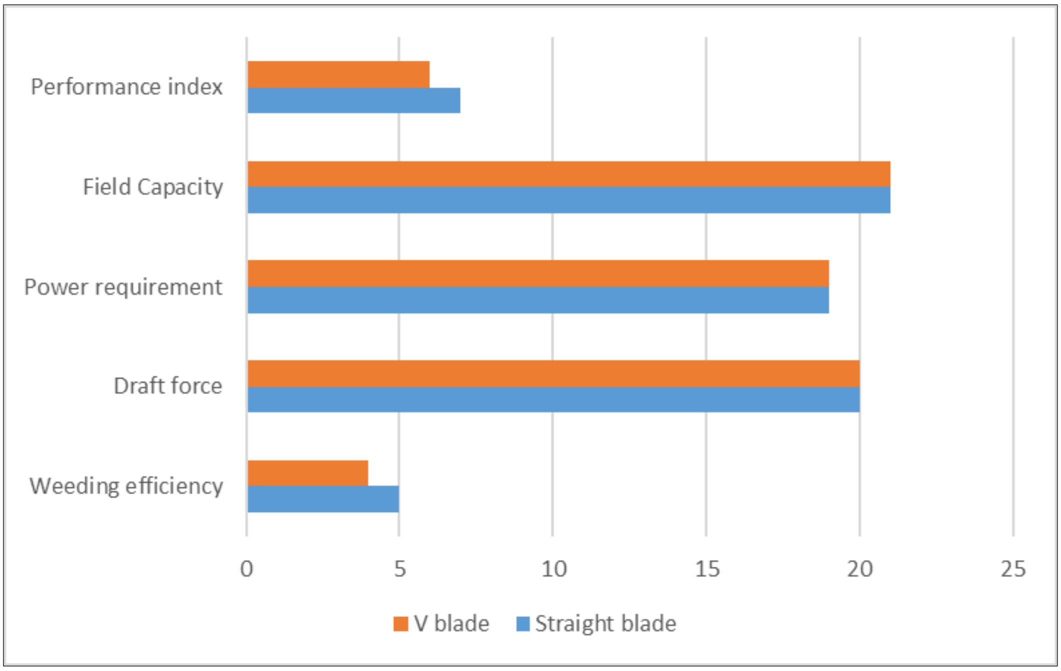

Fig 13: Percentage of increase in field performance of the developed weeders over twin wheel hoe

Due to the increased width of cut (250 mm) compared to the twin wheel hoe, the draft force and power required to run the designed weeders increased; yet, they showed improved field performance with optimum physiological work load. Weeding by developed weeders enhanced the performance by increasing the weeding efficiency, field capacity and performance index to 5, 21 and 7 percent and 4, 21 and 6 percent for straight and V blade weeders, respectively.

It is concluded that the intending to gain a thorough understanding of the pattern of weeders/weeding equipment, as well as constraints of weeders and different weeding techniques in use, to reduce farmers' efforts in terms of money, labour, time, and physical effort. The various intercultural implements were developed in recent years to know the various details about their technical specifications and performances this review work was carried out. This review work was done to know the various intercultural implements used by small and some of the marginal farmers,

Based on the review, the following conclusions were drawn

- Mechanical weed management techniques are the most accessible and have the most impact of all the weed control methods.
- A manually operated weeder is a type of mechanical weeder that provides improved weeding effectiveness while being less harsh.
- The highest weeding efficiency was recorded for Khurpi (99.44%) followed by grubber (96.8%) but using of grubber is a viable option with more field capacity than Khurpi.
- The weeding efficiency of power weeder, wheel hoe and traditional method reported 82.89%, 79.59%and 97.21%, respectively; with the cost of operation of Rs. 1676/ha, Rs 889/ha and Rs 3990/ha, respectively.
- Power weeder was economical to use as compared to Khurpi and its cost of operation was at par with wheel hoe and grubber.

- The most manually operated weeder utilizes very little energy and still works admirably
- A manually operated sprocket weeder showed that, the weeding efficiency of the sprocket weeder was found to be 94.5% with a field capacity of 0.032 ha/h with a time saving of 84 percent and cost of operation Rs. 375/ha with a saving of 79.16 per cent compared to traditional method.
- A manual operated single row weeder for groundnut crop with field capacity of 0.0285 ha/h. higher weeding efficiency was obtained (i.e... up to 80.42%) which is less compared to sprocket weeder but more suitable for groundnut crop.
- The weeding efficiency of the Star weeder is higher than that of other wheel hoes. Wheel hoe and star weeder operation costs were Rs.1696.5/ha and Rs.1785.37/ha, respectively.
- The Mono wheel operated sprayer cum weeder developed, with an actual field capacity of 0.031 ha/h, a theoretical field capacity of 0.0428 ha/h, a field efficiency of 65.54 percent was observed.
- Modified push and pull type cycle weeder was superior when compared with twin wheel hoe and Khurpi, with 83.65%, 0.035(ha/h) and 2.156 of weeding efficiency, field capacity and BCR respectively.

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The authors are thankful to all the scientists and researchers who conducted the research on the use and development of intercultural tools and implements in different part of the country and generated the valuable research data which helps to the farming community for enhancing their productivity are listed in citation.

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