

# TECHNICAL REPORT

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on

## Design & Development of Tractor Mounted Inter-row Rotary Cultivator for Wide Row Crops

Funded by



SERB, DEPARTMENT OF SCIENCE AND TECHNOLOGY (DST)

NEW DELHI, 110 016

### Participating Agencies

Punjab Agricultural University, Ludhiana

CSIR-CMERI Centre of Excellence for Farm Machinery, Ludhiana



CSIR-CMERI CENTRE OF EXCELLENCE FOR FARM MACHINERY

OPP. GNE COLLEGE, GILL ROAD, LUDHIANA - 141 006

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1. **Title of the project:** Design & Development of Tractor Mounted Inter-row Rotary Cultivator for Wide Row Crops
2. **Principal Investigator(s) and Co-Investigator(s):**  
Dr. Baldev Dogra, Research Engineer, PAU, Ludhiana  
Mr. Jagdish M, Scientist, CoEFM, Ludhiana
3. **Implementing Institution(s) and other collaborating Institution(s):**  
Punjab Agricultural University, Ludhiana  
CSIR-CMERI Centre of Excellence for Farm Machinery, Ludhiana
4. **Date of commencement:** 01.01.2010
5. **Planned date of completion:** 31.03.2013
6. **Actual date of completion:** 31.10.2017
7. **Objectives as stated in the project proposal:**
  - ✓ To design and develop a tractor-mounted rotary cultivator for other wide-row crops
  - ✓ To evaluate the performance of the developed rotary cultivator under actual field conditions
  - ✓ Demonstration and field trials at farmer's fields.
8. **Deviation made from original objectives if any, while implementing the project and reasons thereof:** No
9. **Experimental work giving full details of experimental set up, methods adopted, data collected supported by necessary table, charts, diagrams & photographs:**

### Operational requirement and Design consideration

The operational requirement of the inter-row rotary cultivator (Theoretical considerations) are as follows:

- ✓ **Ground Clearance, mm: 600 or more**  
The wide row crops like sugarcane or cotton over-sheds the height of 500-600 mm until completion of 3 weeding operations. Also the ground clearance of the tractor used to be 600 mm.
- ✓ **Depth of working, mm: 50-75**  
Most of the weeds get germinated from top 2 to 5 cm depth of soil layer (Reddy and Reddy, 1992). However, we need little more depth as we have little pulverization of soil to break up the capillaries and earthing up. Secondly the pulverised soil will dry faster and thus re-emergence of weeds will reduce.

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✓ **Bite length, mm: 50-75**

As per the review, most of the rotary cultivators have rotor speed of 300-350 rpm and bite length of 60-70mm. Also the optimum length to be tilled in one bite should to be such that it should not leave any weed in between, weeds get chopped and volume of soil being tilled will be handled easily.

✓ **Working width, mm: 500-550**

As most of the wide row crops like sugarcane, cotton gets cultivated at row spacing of 675 to 900 mm. The covers of the weeding unit have width of 560-580mm and maintaining the remaining space for avoiding the injury to the crop.

✓ **Row spacing:**

(As per agronomic package of practices, PAU, Ludhiana, 2011)

- Sugarcane, mm: 675-900
- Cotton, mm: 675-900

**Selected design parameters for the machine to be developed are:**

✓ **Rotary blade rpm or gear ratio: 300-350, ~1.8**

As per the review, most of the rotary cultivators have rotor speed of 300-350 rpm

✓ **Bite length: 50-75**

As per the review, most of the rotary cultivators have bite length of 60-70mm. Also the optimum length to be tilled in one bite should to be such that it should not leave any weed in between, weeds get chopped and volume of soil being tilled will be handled easily.

✓ **Cutting force of blades, N: 250**

It includes the total static and dynamic forces acting on the blade surface. Static force is dependent on the specific resistance of the soil and the other part dynamic force of rotary blades is dependent on many factors, but major parts of this force are due to energy required for throwing soil layer and to overcome frictional forces. Basically, the dynamic force includes acceleration force, soil - metal friction force and force due to pressure of soil above the blade.

✓ **Shape of blade: Trochoidal J shaped**

Just scratching of the soil is needed along with weeds. However, maximum tillage depth up to 75 mm was considered as this will increase the pulverization of upper soil and will act as a capillary breaking and mulching activity which will suppress the next growth of weeds. Although C - shaped

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blades reduce the energy consumption, but to have greater shearing action perpendicular to soil surface and hence L - Shaped blade serve the purpose but the energy consumption and surface area of the L - shaped blade is quite large. Hence the optimum shape would be J - shape as it has minimum surface area exposed to soil and its performance is also good. Hence, J - Shaped blades were chosen.

According to Sakai (1978), the coiling trouble of grass and straw to the rotary tillers occurred more easily on the soft soils than hard soil and generally weeding is done in tilled or soft soils. The grass removing ability or blade would be better with the edge curve angle and thus the shape formed by the edge curve is called as trochoid.

✓ **Diameter of rotor, mm: 480-520**

As per review the rotor diameters vary between 400-500 mm. Also the blades used for cultivator should have sufficient length to accommodate the trochoidal shape.

✓ **Load on chain, kN: 49.62**

[Selected chain breaking load, kN: 57.8 (IS: 2403-1991)]

As the forces coming on the blade ultimately carried forward to the chain drive, it comes to the conclusion (after calculations) of having this load and ultimately suggests us to select the higher breaking load chain.

✓ **Power requirement for rotary assembly, kW: 7-8**

Calculated from the forces acting on blades and number of blades at a time in action.

✓ **Draft requirement for shovel, N: 1250-1350**

Taking into account the unit draft of heavy soils multiplying it with the cross sectional area of soil slices.

✓ **Placement of gear box: Over the frame or on transmission Shaft.**

✓ **Height of PTO shaft from ground, mm: 650-700 (Standard)**

✓ **Standard 540 PTO RPM**

✓ **Cat-II three point linkages is preferred as majority of farmers opting for inter row rotary weeder will have tractors of 50hp or above.**

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Table.1: Brief design Specifications of inter row rotary cultivator

<b>Sr. No</b>	<b>Parameter</b>	<b>Description</b>
1	Length of frame, mm	2000
2	Number of rotary blade assemblies	Three
3	Number of flanges per basic unit	Two
4	Number of blades per flange	Six
5	Width of cut of each rotary unit, mm	250-500
6	Working Diameter of blades, mm	410
7	Maximum outer width of cover of each unit, mm	600
8	Approximate minimum possible center distance of row crops for weeding, mm	675
9	No of depth wheels	Two
10	Speed ratio at gear box (PTO to sprocket )	2.27
11	Ground clearance	650
12	Square shaft, mm	40 mm
13	Blade.	J type
14	Chain drive speed ratio	1:1
15	Diameter of flange, mm	230

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Fig.1: Developed prototype of inter row cultivator



Fig.2: A view of machine during field operation in sugarcane

Field Evaluation for weeding in Pigeon-Pea crop:



Fig. 3: A view of machine in weeding in Pigeon-pea crop



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Field evaluation of machine in Pigeon-Pea crop

S. No.	Parameter	Observations
1.	Location	Research Farm of DFMPE
2.	M. C. of the soil %	13-16
3.	Type of soils	Sandy loam
4.	Crop and variety	Pigeon-pea, AI-201 & PAU-881
5.	Row spacing of the crop, cm	67.5
6.	Age of crop , days	48-52
7.	Plant height, cm	52-55
8.	Effective width of coverage, cm	202.5
9.	Speed of operation, km/h	2.5-3.0
10.	Field capacity, ha/h	0.34-0.38
11.	Field efficiency, %	68-72
12.	Fuel consumption, l/h	4.8-5.2
13.	Weed intensity before operation, g/m <sup>2</sup>	84-102
14.	Weed intensity after operation, g/m <sup>2</sup>	18-28
15.	Weeding efficiency, %	72-78
16.	Percentage plant damage, %	2.5-3.5
17.	Mixing index	66-70
18.	Area covered, acre	1.5
19.	Crop damage, %	2-2.5
20.	Re-emergence, %	
	After one week	5-6
	After two weeks	15-16
21.	Machine breakdowns	Nil

Taking consideration above results further modification was done to improve the performance of machine. A technology package was developed for this improved machine to transfer technology to manufacturers. As this machine was constantly demonstrated and popularized since development twice in a year in Kisan Melas, at PAU and different KVK's in Punjab and field days and in various workshop which were held at PAU, Ludhiana and COEFM Ludhiana.



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### 10. Conclusions summarizing the achievements and indication of scope for future work:

The project was initiated by PAU and CSIR-CMERI-COEFM Ludhiana in collaboration for design & development of tractor mounted inter row rotary cultivator for wide row crops. A state of the art machine has been designed and developed by CSIR-CMERI-COEFM. Preliminary and exhaustive testing of the cultivator has been carried by PAU, Ludhiana. The preliminary lab testing and field testing of inter-row rotary cultivator was carried out in research hall and farm of the department of Farm Machinery and Power Engineering, PAU, Ludhiana. No breakdown was observed during the laboratory operation. Effective field capacity of machine is 0.30-0.79 ha/h. Field efficiency ranged from 80-85%. Approximately 50cm of soil strips was tilled by each weeding assembly of the machine.

The field evaluation of machine in sugarcane crop was carried out at Research Farm of Regional Research Station, Kapurthala. The machine was operated in the field about on more than 25 ha. Sugarcane planted at row to row spacing of 67.5, 75 and 90cm was weeded. The machine was evaluated in field for weeding in Pigeon-Pea crop in an area of 1.5 acre at research farm of department. The machine was also evaluated for weeding in vegetables crop viz. radish, onion and cabbage in an area of 12 acre (4.8 ha). These vegetables were planted at row to row spacing of 65 and 67.5 cm for seed production at University Seed farm (USF), Ladowal. The machine tilled soil strips of approximately 50cm between two rows of wider row crops. Three soil strips were tilled simultaneously. In general field efficiency was low around 70% as no head land was available for tractor turning and requiring engaging and dis-engaging of PTO gear at every turn. The plant damage during weeding operation in vegetables crop was just the damage of leaf and some other parts of plants but there was no complete plant damage. The performance of this machine was better when compared with tractor operated high clearance cultivator and sweep type cultivator. Tractor operated high clearance cultivator and sweep type cultivator being utilized for weeding operation formed bigger clods of soil. Approximately 10 percent of these clods cover the complete plant. In weeding operation performed by high clearance cultivator and sweep type cultivator, complete plant damage was observed from 10-12 percent.



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Features	Specifications
Working Depth adjustable.	Machine width: 2000 mm
Suitable for Indian condition	Row Spacing: 40-60 cm
High ground clearance.	Number of rows: Three
Row Spacing adjustable.	Working width: 300-460mm
Working width adjustable.	Weight of machine: 450kg
	Power, HP: 35-45HP

### Achievements

- ✓ Four prototypes have been developed
- ✓ Technology package prepared
- ✓ Technology has been transferred to three industries

### Technology Transfer



**M/s Maghar Singh Matharoo & Sons**  
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Industrial Area-A,  
Ludhiana-141 003, Punjab



**M/s Nascent Agrimach**  
#89/3P, Street No.5,  
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Daba Road,  
Ludhiana-141 003, Punjab



**M/s Raftaar Professional Engineering Company**  
Shed No.10, STEP,  
Near GNE College, Gill Road,  
Ludhiana-141 006, Punjab

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### 11. S&T benefits accrued:

#### I. List of Research publications

S No	Authors	Title of paper	Name of the Journal	Volume	Pages	Year
1	S P Modak, Baldev Dogra, Ritu Dogra, Dinesh Kumar	Design of Rotary Weeder Blade	Agricultural Mechanisation in Asia, Africa and Latin America			Paper No 2014-21

#### II. Manpower trained on the project

a) Research Scientists or Research Associates: 04 nos.

b) No. of Ph.D. produced: Nil

No. of M.Tech produced: 02 nos.

No. of B.Tech produced: 08 nos.

c) Other Technical Personnel trained: Nil

#### III. Patents taken, if any: No