TECHNICAL REPORT

on

Design & Development of an Offset Rotavator for Orchards

Funded by

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Participating Agencies

Punjab Agricultural University, Ludhiana

G. B. Pant University of Agriculture and Technology, Pantnagar

CSIR-CMERI Centre of Excellence for Farm Machinery, Ludhiana

CSIR-CMERI CENTRE OF EXCELLENCE FOR FARM MACHINERY

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TECHNICAL REPORT

1. **Title of the project:** Design & Development of an Offset Rotavator for Orchards
2. **Principal Investigator(s) and Co-Investigator(s):**
   Dr. Baldev Dogra, Research Engineer, PAU, Ludhiana
   Dr. R.N. Pateriya, Professor, GBPUA&T, Pantnagar
   Mr. Jagdish M, Scientist, CoEFM, Ludhiana
3. **Implementing Institution(s) and other collaborating Institution(s):**
   Punjab Agricultural University, Ludhiana
   G. B. Pant University of Agriculture and Technology, Pantnagar
   CSIR-CMERI Centre of Excellence for Farm Machinery, Ludhiana
4. **Date of commencement:** 01.09.2010
5. **Planned date of completion:** 31.03.2013
6. **Actual date of completion:** 31.03.2018
7. **Objectives as stated in the project proposal:**
   - ✓ To test and evaluate the performance of the commercially available (India & abroad) offset rotavator under laboratory and field conditions.
   - ✓ Design and prototype development of an offset rotavator for intercropping & intercultural operations in orchards under Indian conditions.
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:**
   <u>Shaktiman offset rotavator</u>
   Field evaluation of Indian offset rotavator was done at popular tree orchard PAU. From the field test it was concluded that
   - ✓ Response time of side shifting mechanism is too slow.
   - ✓ There was more plant damage (about 18.3 %) with the implement, so that the offset rotavator was not fond suitable to test in other orchards. It was recommended that the plant damage percentage should be zero.
   - ✓ Very Skilled tractor operator is required to operate the offset rotavator.
   - ✓ Operator has to concentrate on forward as well as backward of tractor and to control the forward direction of motion and lateral movement of rotavator simultaneously. He has to look backward most of the time, therefore there is more drudgery and muscular fatigue to the operator.

- ✓ Some area were left around the tree, because the time taken by rotavator from offset to no-offset position is 3 sec, so the operator has to push the hydraulic lever atleast 1.46 m (or 3 sec) before the tree trunk comes.

Fig.1: Operational view of rotavator and rotavator shield contour

Fig.2: Operational view of rotavator and rotavator shield contour

Rineri offset rotavator

The Field performance of the automatic hydraulic shift offset rotavator manufactured by Rineri, Italy, was evaluated by PAU centre. The offset rotavator was evaluated for different orchards (Kinnow, Pear and popular tree farm). From the field test it was concluded that

- ✓ Response time (1 s) of side shifting mechanism is fast.
- ✓ There was less plant damage (6.2%) with the implement. However, zero damage to plants is desired, even at the cost some area left uncovered near to plants.
- ✓ Effective width of operation is very low (750 mm), so the field capacity (0.074 ha/h) of the machine is also very low.
- ✓ Sometimes the rotor blades got struck or the side shift mechanism of offset rotavator is got struck due to heavy weeds/ undulated field near trees. In such conditions the joining bolt of PTO shaft was broken. This happened 4 times in 3 hour operation of rotavator in popular farm.

- ✓ A Skilled tractor operator is required to operate the offset rotavator. However due to automatic side shift mechanism, the driver has to concentrate only towards forward direction. Hence, fatigue to driver is also less.

Fig.3: A view of Rineri rotavator and field after operation.

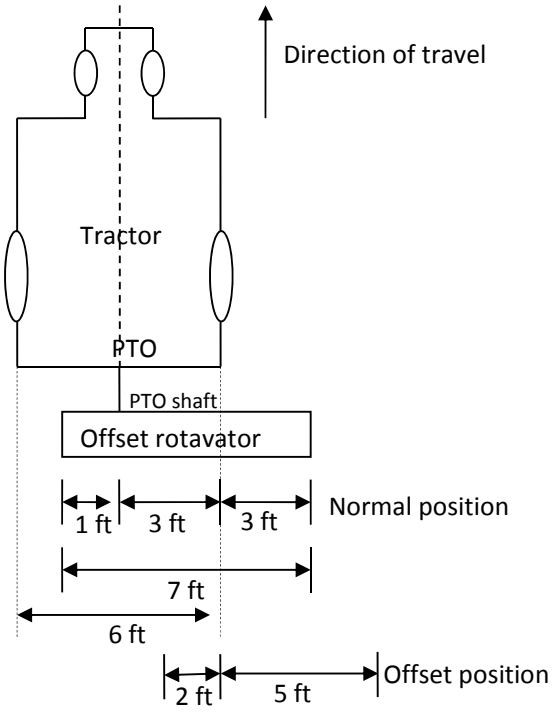
Fig.4: View of plant damage due to rotavator shield contour and weed left after operation.

Table 1: Comparison of Shaktiman and Rineri offset rotavator for different parameters

S.N.	Parameter	Shaktiman rotavator	Rineri rotavator
Machine parameters			
1	Width of implement, mm	2000	2000
2	Effective width of implement, mm	1780	750
3	No. Of blades	42	33
4	Type of blades	L – Type	C – Type
5	No. Of flanges	8	6
6	No. Of blades per flange	6	6/last 3
7	Distance between consecutive flanges, mm	200	110
8	Weight of machine, kg	480	360
9	Amount of achievable offset position, mm	380	600
Field evaluation			
10	Width of operation, cm	176	60
11	Depth of operation, cm	13.5	5.1
12	Plant damage, %	18.30	3.00
13	Response time (side shift), seconds	3.00	1.00
14	field efficiency, %	54.80	48.80
15	Soil bulk density index, %	19.18	23.31
16	Plant damage, %	18.30	3.00
17	Response time (side shift), seconds	3.00	1.00
18	Number of passes required to cover 6 m row to row space	4	11
19	Fuel consumption, litre/hour	6.83	5.91

Design guidelines for offset rotavator

- ✓ The rotavator must have provision of automatic hydraulic side shift mechanism, so that the damage to plants and also human fatigue can be minimized.
- ✓ Damage to plants due to machine should be almost zero. The shield contours of the rotavator should be curved and shaped so as to avoid strike with plant. Wheels can be deployed for depth control system and should be placed in such a way so that there is a considerable clearance from the end of the rotavator.
- ✓ The effective width of the rotavator can be about 2.13 meter (7 feet) with 0.91 m (3 feet) of achievable offset position. So the performance of the machine is better in terms of field efficiency and field capacity.
- ✓ There should be provision of an offset lock in rotavator because also it is equally important to cover the whole field area rather than concentrate on the area near trees only.



The above findings were discussed at third meeting of the Project Monitoring Committee held on 20th august, 2013 and following broad specifications were finalized for an offset rotavator for Indian conditions:

- Effective working width : 1500 mm
- Provision for depth of cut of blades : 100 mm
- Minimum offset : 400 mm
- Power source : 40-45 hp

Developed Offset Rotavator:

Description of the offset rotavator

An offset rotary tiller is a P.T.O operated tractor mounted implement which is used for the pulverization of soil as secondary tillage operation as well as weeding purpose in orchard or in agro forestry fields. It operates in between plants by mounting on three point linkage mechanism and tractor is used as prime mover. The tractor drawn offset rotavator developed by CSIR – CMERI Ludhiana was evaluated in lab and field conditions by PAU centre is shown in figure 1.An important feature of the unit is side shift system (perpendicular to the line of motion), based on a hydraulic cylinder, that is activated by a sensor fitted in side of the rotary tiller. The rotavator is tractor rear mounted pto operated hydraulic side shift machine. The offset position of the rotavator can be controlled by hydraulic system which is operated by a sensor. Sensor touches the tree and pushes the hydraulic valve to side shift the machine automatically and make it normal position behind the tractor. When the sensor passes the tree trunk and comes in free position the rotavator moves in offset position again.

For operation of hydraulic control system pto power of tractor is used. PTO of tractor runs the hydraulic system and also the rotavator blades. The power from the pto is transmitted to the rotor shaft through universal shaft, gear box and the chain drive mechanism. The rotavator is mainly used for tillage and intercultural operations in orchards. An important feature of the unit is side shift system, based on a hydraulic ram that, activated by the sensor. It is a hydraulically operated, automatic controlled side shift rotavator. A double acting hydraulic cylinder is provided to adjust the offset position of rotavator according to requirement of orchards. The rotavator can be moved laterally up to 370 mm. A curved shield is provided at the rear of rotavator blades as a safety device and for better pulverization. Specifications of the machine are given in following table.

Table 2: Specification of developed offset rotavator

S. No.	Particulars	Specifications
1	Width of implement, mm	1960
2	Effective width of implement, mm	1800
3	No. of blades	35
4	Type of blades	L – Type
5	No. of flanges	7
6	No. of blades per flange	5
7	Distance between consecutive flanges, mm	250
8	Diameter of rotor shaft, mm	100
9	Gear box type	Bevel pinion gear
10	Hydraulic cylinder	One, Double acting
11	Weight of machine, kg	550
12	Amount of achievable offset position, mm	370
13	Amount of total offset position, mm	1590

Fig.5: RearView of Offset Rotavator

Fig.6: Front View of Offset Rotavator

Lab testing:

Preliminary test was conducted in Department laboratory to check the operation of hydraulic system of rotavator, speed of rotor at different engine speed and to measure time taken for lateral movement of rotavator from no offset position to offset position. From the lab test it was found that at 1500 rpm of tractor engine, the time taken for lateral movement of rotavator was 1.0-1.5 seconds. Also about 370 mm amount of offset position was found by lateral movement of Rotavator.

Fig.7: Offset rotavator during initial trial

Fig.8: View of a young Pear orchard after offset rotavator

Fig.9: View of Pear orchard before and after offset rotavator

Fig.10: Limitation of offset rotavator in case of low height branching

Interaction with stake holders:

The technology was demonstrated to various stake holders viz. Experts from PAU, Extension specialist from PAU and Department of Horticulture, Government of Punjab, members of Punjab State Agricultural Implements Manufacturers Association (PSAIMA), and farmers.

Fig.11: Presentation about offset rotavator during Horticulture Workshop at PAU, Ludhiana

Fig.12: Demonstration of Offset rotavator to Extension Specialists of PAU and Deptt of Horticulture, Punjab

Fig.13: Demonstration of Offset rotavator to Punjab State Agricultural Implements Manufacturers at PAU

Fig.14: Demonstration of offset rotavator to farmers during Kisan Melas at PAU Ludhiana

10. Detailed analysis of results indicating contributions made towards increasing the state of knowledge in the subject:

S. No.	Activity	Organizations
1.	(a) Field performance evaluation of available/imported offset rotavators. The following operational parameters shall be established for different soil type and conditions- • Working width • Number and type of blades • Speed of rotor • Forward speed of tractor	PAU & GBPUA&T
	(b) Design standardization of • Power transmission • Blade layout Blade shape and size • Material for construction of blades • Other adjustment mechanism	PAU & GBPUA&T
2.	Operational requirements of the rotavator to be studied, verified and selected.	PAU & GBPUA&T
3.	Selection of design parameter & preparation of design brief.	All centre
4.	Conceptual design and standardization of the offset rotavator components for fabrication	All centre
5.	Fabrication of prototype of offset rotavator machine	CoEFM, Ludhiana
6.	Performance evaluation of the developed prototype of offset rotavator & demonstration at farmer's fields.	PAU & GBPUA&T
7.	Transfer of manufacturing technology to participating Industry.	PAU & GBPUA&T

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

- ✓ The tractor operated offset rotavator for fruit, trees and agro forestry crops was approved by the Research Evaluation Committee of PAU, Ludhiana during 263rd meeting held on 08.08.2017 at PAU, Ludhiana.
- ✓ The tractor operated offset rotavator was included in Package and Practices for Fruit Crops (English as well as Punjabi) for adoption by the Punjab farmers.

- ✓ The tractor operated offset rotavator was demonstrated to farmers, Research and Extension Specialist and Agricultural Implement Manufacturers of Punjab State.

12. S&T benefits accrued:

I. List of Research publications

S No	Authors	Title of paper	Name of the Journal	Volume	Pages	Year
1.	R.N. Pateriya, Pal R Bhimwal	Evaluation of an offset rotavator for different type of orchards	Annals of Agricultural Research, New Delhi	36(3)	262-268	2015

II. Manpower trained on the project

a) Research Scientists or Research Associates: 07 nos.
b) No. of Ph.D. produced: Nil
c) No. of M.Tech. produced: 03
d) Other Technical Personnel trained: Nil

III. Patents taken, if any: Jagdish M, Pradeep Rajan, Paramjeet Singh, Ajay Yadav, (2017) Automatic transverse moving tiling unit for orchards (INDIA) (Filed: 25.05.2017) (FILED)