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DESIGN AND DEVELOPMENT OF TWO ROW TRACTOR OPERATED POTATO COMBINE HARVESTER

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ABSTRACT: Potato harvesting is one of the most important operations, which have to be performed precisely, to have good quality potatoes. A two row tractors operated potato combine harvester having provision for side conveying of the harvested potatoes in the trolley, has been designed and developed. It consists of seven major unit's *viz*. main frame, digging system, elevator conveyor, side delivery / discharge conveyor, trash separation and soil sieving system, power transmission and transport system. The prototypes functions to dig out, separate dug tubers from soil mass, conveys, elevates and fill in a trolley. The effective field capacity of the potato combine was found as 0.26 ha/hr.

KEYWORDS: Potato combine harvester, two row, tractor operated

INTRODUCTION

Planting and harvesting are the two most labour consuming operations for the production of potato crop. Potato harvesting is one of the most important operations, which have to be performed precisely, to have a good potato production. Potato is grown on the ridges or beds. Tubers lie buried underground while leaves and stems remain outside. Harvesting the potato crop is a critical part of the entire potato production and marketing operation. The unit operations involved in potato harvesting include) cutting or destroying of the potato haulms before harvesting operation, ii) breaking the soil potato ridges and exposing the tubers with a view to collect them easily and efficiently, iii) digging, lifting and conveying the soil potato mass with an aim to separate the potato from soil and stem and iv) collecting the tubers with minimum injuries.

Manual harvesting of potato requires 600-700 man hours (h) / hectare and accounts for nearly one third of the total labour requirements for the production of this crop (Verma *et al.*, 1992). Although the machines are available and used for mechanical harvesting of potato, but the picking and collection of dug tubers is invariably carried out manually. Apart from being full of drudgery, it is also a time and labour consuming operation. The acute shortage of labour is being faced by the potato growers now a day, especially at the time of harvesting. The tractor drawn implements for potato harvesting are the raising plough diggers, spinner diggers and digger elevators. With increasing production of potatoes and diminishing supplies of suitable labour, the development of a potato combine harvester, is the need of the hour. The potato combine harvesters enable a one-stop achievement of potato digging, soil-potato separating, trash removing, potato conveying & collecting procedures. It effectively decreases the labour cost and enhances the production efficiency.

One and two row potato combine harvesters are commonly used in the western countries. Attempts were made at the PAU, Ludhiana to develop a single row potato combine during early seventies. Two prototypes were

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developed. Both of them were single row machines. The first prototype comprised of a primary conveyor, a cross conveyor and a sorting belt conveyor. Whereas the second machine employed a rotary cage screen in place of cross conveyor. The preliminary testing of these machines showed considerable promise but the efforts were not pursued further due to variety of constraints which ruled out the possibility of their introduction and large scale adoption in India at that time (Verma, 1976). The total cost of mechanized harvesting was 49.03% less than the total cost of the semi mechanized harvesting. The effective operating capacity of mechanized harvesting was greater than the semi mechanized harvesting. On an average, the harvester performed a work relating to 23 labourers in manual collecting and mechanized harvesting showed losses of 2.35% as compared to the productivity of the area, while semi-mechanized harvesting showed losses of 6.32% (Joao *et al.*, 2011). A potato digger cum elevator was designed and constructed, which is capable of digging potato with a minimum injury, working on the principle of digging and elevating the soil and potatoes, simultaneously (Reddy *et al.*, 2017). A multipurpose digger for harvesting potatoes as well as separating and transporting them over soil surface with minimum losses, mechanical damage, has been developed. Potato harvester is developed by adding a successful vibrating separating mechanism that should base on separating potatoes with minimum losses and damage. (Bangar *et al.*, 2016).

MATERIALS AND METHODS

The harvesting and collection system of 2-row tractor operated potato combine harvester, was designed and fabricated. It consists of seven major units *viz*. main frame, digging system, elevator conveyor, side delivery / discharge conveyor, trash separation and soil sieving system, power transmission and transport system (**Fig. 1**). The prototypes functions to dig out, separate dug tubers from soil mass, conveys, elevates and fill in a trolley. Various components of the digger are described in (**Table 1**).

Main frame

It is rectangular in shape with rear side projected upward and is fabricated using MS channels and MS angles. The sides of the

Fig. 1. Tractor operated potato combine harvester.

Table 1. Components of the prototype of potato combine harvester.

Sl. No.	Item	Specifications
1	Type	Tractor operated, 2-row trailed type
2	Overall length (mm)	4250 mm
3	Overall width (mm)	3750 mm
4	Overall height (mm)	2150 mm
5	Power transmission	From tractor PTO shaft through differential gear box to chain conveyors using V-belt pulleys (B -124) and chain sprockets
6	Elevator chain Type	Rod chain conveyor, with provision for shaking of chain with eccentric vibrators, power sprockets, side pulleys
7	Side delivery chain Type	Rod chain conveyor, swan neck type with wooden flights
8	Digging cum conveying system	Fixed blades/ side discs /rod chain conveyor type
9	Power transmission	From tractor PTO shaft through differential gear box to chain conveyors using V-belt pulleys (B -124) and chain sprockets
10	Transportability	Machine supported on three pneumatic wheels (19 × 6.25) fitted to main frame

frame are covered with MS sheet. The frame houses and supports the digging blades, differential gear box, elevator rod chain conveyor, shafts of side pulleys, vibrators, main drive sprockets and the pneumatic transport wheels.

Digging system

The system comprises a digging share blade, fixed in front of the elevator and attached to its frameset to cut beneath the lowest potatoes. It consists of two HC steel blades of triangular shape with side discs and a central set of discs, supported with the main frame. The width of each blade is kept as 400 mm and blade to blade spacing is kept as 600 mm, thus making the prototype suitable to harvest crop planted at 600 mm row spacing. The blades are supported from their lower surface with the main frame with 50 × 25 mm size curved supports. The stone deflectors system is provided behind the digging blades. Diabolo rollers were provided over and in front of blades to reduce the formation of clods during harvesting in heavy soils, which facilitates better separation and avoid injury to the tubers from soil clods.

Elevator conveyor

The elevator conveyor is rod chain type of length of 5200 mm and consisting of 135 rods. It is made of 12 mm diameter MS rods with end pressed, drilled and fitted at a spacing of 30 mm from adjacent rods on the 50 mm × 4 ply rubber belt from both sides and also at the centre. The rod chain is supported from the rear with drive supports and from the front with digger pulleys. Two numbers of agitator sets are provided. The supports are also provided below the chain to reduce excessive sag.

Trash separation and soil sieving system:

An inclined rod chain type conveyor for trash separation and soil sieving system was also designed, fabricated and attached with the prototype. This rod chain type conveyor having length 1070 mm and width 725 mm, consisted mainly of 57 numbers of 12 mm diameter MS rods with pitch of 25 mm. The trash separation and soil sieving system, was attached with the help of two shafts supported by bearing brackets. A wooden roller of diameter 100 mm has also been provided in this system to maintain the proper tightness

of the system. Power to this trash separation and soil sieving system, has been provided from the rear shaft of the primary elevator rod chain conveyor through chain and sprockets arrangements. The system is located behind the prototype immediately behind the primary rod chain. It receives the material from the primary rod chain conveyor, sieves the soil and allows the tubers to roll down in the lateral conveyor for their further transportation to trolley. The trash is dropped down behind the machine.

Side delivery/ discharge conveyor:

The tuber collection and lateral conveying system of the prototype combine harvester to fill in the tractor trolley with dug potatoes, was fabricated and integrated with the prototype harvester. The design consists of a swan neck shaped elevator conveyor, which functions to receive the dug tubers along with the soil mass after sifting on the primary conveyor, transports, elevates and drops it in the trolley. It consists of an angle iron frame made of 75 × 75 × 9 mm angle iron sections curved at 2 places to give it a Z- like shape. It supports a rod chain conveyor, which is made 3900 mm long and 600 mm wide. It is made of 12 mm diameter MS rods riveted on both sides over a 3 ply and 5 cm wide rubber belt. The spacing between adjacent rods is kept as 15 mm. The rod chain is supported at both ends with the help of 11 teeth and 150 mm diameter sprockets and also in between at both the bends. The rod chain conveyor is provided with supports from upper and lower side. The chain is also supported from below with PVC rollers. The sprockets with special platform are also provided on the first curve to the chain, to tight press the chain and keep the first portion as horizontal. The second portion is provided steep inclination, while the third portion is given mild inclination only. The lateral tuber conveying system as developed separately was integrated from behind the main digging and conveying system of the research prototype. Wooden pieces have also been provided on the conveyor at equal intervals for conveying of the dug material. To disallow falling of the small tubers through the conveyors, MS rods of diameter 6 mm have also been welded in the centre of the spaces between the conveyor main rods of this system. The system is attached to main system with channel and angle iron supports with nut bolts and is thus kept detachable.

Power transmission system: The power transmission system consists of a differential gear box which is driven with the PTO of the tractor through a universal joint. The power is provided from the gear box to the rear of main elevator chain through V-Belt pulley drive. Further the power to the side conveyor is transmitted with the help of a suitable chain and sprocket arrangement.

Transport system: The transport system of the prototype consists of three pneumatic wheels (size 19 × 6.25) for adequately bearing the weight of the prototype and for its proper transportation and operation in the field. The prototype machine was made suitable for operation along with trolley, moving on its left side from front for filling of dug tubers, as received from the machine. The important specifications of the experimental research prototype are given in **Table 1**.

RESULTS AND DISCUSSION

The tractor operated potato combine harvester (**Fig. 1**) was tested at the farms of the Central Potato Research Station, Jalandhar. During actual field operation two tractors are required one to operate the machine and the second one to carry the trolley to receive the dug material.

Operation and performance of the Machine

The machine digs out the two adjacent potato ridges simultaneously with the help of digging blades. The soil potato mass is passed

on to the rod chain type elevator conveyor. The discs set at the sides and in the centre facilitate the flow of dug material to the elevator conveyor. The material is lifted, conveyed and separated from the soil by sifting through the rod gaps. The elevator chain is agitated with the help of eccentric vibrators at two different locations of the chain conveyor. The potato tubers separated from the soil mass are passed on to the side conveyor. The material is moved to the side and then taken upward while separating the left over soil. The tubers then gets dropped in to the trolley. To check clod formation during harvesting, two dicone diabolo rollers are provided at the front side of the prototype, one each fitted above the lifter shares or digger blades. The position of rollers can be adjusted with respect to blade to vary the pressure on the ridge. More the roller pressure, better the fragmentation of the ridge soil, thus the reduced size of the clods facilitates their sieving down from the gap in rod chain. This led to better separation of soil from the potato tubers thus the delivery of clean tubers in the final collection. The prototype could conveniently be operated with a 40 HP tractor. The effective field capacity of the prototype was found to be 0.26 ha/hr. Tuber bruising was observed as 6% during the operation. The prototype functioned satisfactorily under the sandy to sandy loam soils with optimum soil moisture and weed free conditions at harvest. The combine can easily be transported to any working site with the help of three pneumatic wheels (size 19 × 6.25) provided with the prototype. 98.4% of dug tubers are collected in the trolley with field losses as 1.6%. It effectively decreases the labour cost and enhances the production efficiency.

Table 2. Performance evaluation of the prototype of potato combine harvester.

1	Effective field capacity	0.26 ha/hr.
2	Labour requirement	4
3	Speed of operation	2.7 Kmph
4	Tractor power requirement	40 HP
5	Tuber bruising	6%

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LITERATURE CITED

Bangar VT, Jadhav SR, Patil KD and Biradar VUO (2016) Design and development of potato harvester. IJARIIE-ISSN (O)-2395-4396. **2** (3) : 3343-3347

Hevko RB, Tkachenko IG, Synii SV, Flonts IV (2016). Development of design and investigation of operation processes of small-sclale root crop and potato harvesters. *INMATEH Agric Engineering*. **49** (2): 53-60

Joao P A R Da Cunha, Daniel HM, Walter G Da Cunha (2011) Operational performance of the mechanized and semi-mechanized potato harvest. *Eng Agríc, Jaboticabal*. **31** (4): 826-34

Reddy P, Moses ASC and Rana NA (2017) Development of adjustable elevator for tractor drawn potato digger. *Inter J Agric Sci Res* **7**: 119-28

Verma SR (1976) Some investigations on oscillating inclined blade for potato harvesting PhD Thesis (Unpublished) Indian Institute of Technology, Kharagpur

Verma, SR, Kalkat HS, Singh CP and Garg IK (1992) Development of potato harvesting equipment and the challenges ahead. In proceedings of National Colloquium on potato mechanization in India, Ed. SR Verma *et al.*, held at PAU, Ludhiana (Pb.) on Nov., 11-12, 59-79 p.

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