

Self-Propelled Onion Harvester

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Abstract

As to certain the increases the farm income that predominantly relies on human resources by mechanizing Welsh onion harvesting a tractor mounted onion harvester was developed in this study. An experiment for evaluating harvesting performance was performed for the developed onion harvester in an actual onion farm. the harvest performance was evaluated at the tractor running speed of 5.0 cm/s, 11.4 cm/s and 15.8 cm/s, by comparing the operating efficiency ,harvest rate, and damage rate of the welsh onion harvester. The performance of the harvester was rated as very good, with a 100% harvest rate, regardless of tractor running speed.

The developed onion harvester is believed to improve the labour productivity and cultivation environment of onion farmhouse by the mechanization of the harvesting process that is currently associated with the largest amount of labour hours. The present research work has been carried out to bring out the reliable solution for harvesting of onion crop. The harvesting of onion crop is the labour intensive operation.

Keywords: - Digging system; cleaning conveying; Collecting and unloading; Transmission system

INTRODUCTION

Operation within specified time limits; preopening the operation affects the keeping quality of onions adversely. On the other hand, labour scarcity delays the

harvesting operation, which may cause

damage to bulbs in adverse conditions. Mechanization of onion harvesting is, thus, essentially needed. Fruits and vegetables are important for the food and nutritional security of the vast population of our country. The choice of varieties of food

consumed is changing from the traditional staple cereals to high value foods such as fruits and vegetables, meat, dairy and fish. India has made a quantum jump in vegetable production starting from 28.36 million tons in 1969-70 to 72.83 million tons in 1997-98. The present vegetable production in India is 113.5 million tons in an area 7.2 million hectare with an average productivity of 15.7 t/ha (Singh, 2007).

In addition to the demand for local consumption, there is an increased demand of vegetables as one the most potential commodities for export (Kallo, 1998). The value of fresh, canned and dehydrated vegetables export has been to the tune of Rs 670.47 crores during 1997-98 accounting for 45.19 per cent of the export of horticultural products. The per capita consumption of vegetables in India has increased from 95 gram to 175 gram per day, but it is much less than the nutritional requirement of 285 grams per capita per day for a balanced diet. Vegetables contain psychochemical's that have anti-cancerous and anti-inflammatory properties which confer many health benefits. The major vegetables grown in India are potato, brinjal, tomato, onion and most preferred winter vegetables cauliflower and cabbage. Onion (*Allium Cepa L*) is one of the most important commercial bulbous vegetable

crops grown in India from ancient times. The area under onion is about 7 per cent of total area under vegetables in the country (Anonymous 2004-05). In terms of area, India ranks first in the world with over 0.48 mha accounting for around 21 per cent of the world area planted with onion. Globally, the country occupies the second position after China in onion production with a production share of around 14 per cent. Productivity, however, is around 11.72 t/ha, which is lower than the world average of 18.45 t/ha as well as Asian average of 16.80 t/ha.

NECESSITY

Introduction of harvesting devices, reduce the time of operations and avoid the losses due to adverse weather conditions during harvesting; the saving in time in harvesting may be utilized for post-harvest processes to increases storage life of the vegetable. Also, most of the vegetables are perishable in nature; hence need proper and careful harvesting, handling and storage before processing or consumption. Mechanization of horticultural crops is at a very low level in the country. Most of the operations, except field preparation, are manual requiring high amount of labour and drudgery. Harvesting of onion crop at proper maturity stage is essential factor in deciding storage life of onion; the bulbs

may be stored for about six months. Traditionally, the well matured bulbs are harvested by pulling out by hand if the soil is not hard or compact, otherwise, they may be dug out with shovel or khurpi.

The harvested crop is left in shade again for curing for about a week. Both the operations i.e. digging and top removal are done manually which is very tedious, time consuming and costly. Besides, it is necessary to complete the harvesting operation within specified time limits for reduced harvest losses and higher storage life. The period of time available to harvest onion is limited. In the first place, sufficient growing time must be allowed for the crop to 'bulb up' and produce the yield. The longer the bulbs are left in the field after maturity the more they are subjected to infection by decay caused by rot organism.

Digging System:

The main function of this system is to loosening the soil and dig out the onion bulb from the soil without damaging the onion. It also conveys the soil layer with onion towards the separating system. Digging system consists of breaking the compact surface of earth to a certain depth and to loosen the soil mass, so as to enable the roots of the crops to penetrate and spread into the soil.

Properties of soil at onion harvest:-

An important component of the proposed onion digger is the share, which is engaged in the soil to dig up the onion bulbs and transfer it to the conveyor. Therefore, the soil parameters play important role in designing the onion digger. The following soil parameters were observed in the onion plot before the harvesting:

- Moisture content
- Bulk density
- Cohesion and angle of internal friction
- Angle of soil-metal friction

The digger blade is an important component of the onion digger. Design and selection of the blade considerably affect the draft and damage of the crop. The review on this is presented in view for onion digger blade Johnson (1974) conducted experiments on a vibrating blade for its use on potato harvester and found that the vibrating blade was successful in meeting most of the design criteria. The blade performance was observed for a range of vibration speeds (0 to 700 strokes/min) and stroke length (0 to 20 mm) at varying rake angle of the blade from 10 to 30°. The study revealed that a vibrating blade for a potato harvester was feasible. The vibration caused a rapid break-up of the soil and assisted in

separation of soil from potatoes. A large portion of the potatoes was separated from the soil by the time the material dropped from the tines. Material flow into and over the blades was obtained with no observed spill out. Flow of material and soil separation was better at the longest stroke of 20 mm. It appeared that even a further longer stroke may be an improvement.

Vibration speed should be at least 450 strokes/ min for good soil separation and feeding. Only slight additional improvement was observed at speed above 450 strokes/min. There was no observed difference with a change in blade angle from 10 to 30°. Shape of the tine had no observed effect & maximum tine length for satisfactory feeding was 450 mm. Verma (1977) conducted the experiment on potato digger with oscillating blade. It was justified the adoptability of an oscillating tool to a root harvesting machine which gave reduction in draft and better soil break-up.

The experimental potato digger with oscillating blade was tested at frequencies up to 9 Hz and amplitude up to 30 mm with an arc motion coinciding with forward motion of travel. The oscillatory blade reduced the draft up to 76 per cent and increased the soil separation up to 96 per

cent. Sharma et al. (1986) designed and developed an oscillatory potato digger.

CLEANING CONVEYING AND SEPARATING SYSTEM

The width and height of the throat of the digger was determined keeping in view the ease of flow of material on separating unit. The width of the throat was limited to 1 m because of the size of the blade selected. The height was determined on the basis of height of onion leaves so that it should not get damaged during the operation and material handling by the digger. The maximum depth of operation of the digger was selected as 100 mm based on the distribution of bulb in the soil. Considering the average height of the onion plant 300 mm and the depth of operation 70 mm, the total height of the soil-onion plant including was 307 mm.

After lifting of soil-onion the volume would increase by 1.5 times of the original volume based on cut-fill ratio of the soil. The other material like weed etc. may also pass through the throat. Therefore, a clearance of 100 mm was provided in excess of the height of material. The total throat height of the digger was thus decided as 400 mm. The design of the separating unit was based on its functional requirements. To determine the size of

conveyor the width of the conveyor was selected as 1m on the basis of tread width of the tractor. Determination of power consumption of separating unit A 2 hp single-phase AC motor having 1440 rpm was used to drive oscillating conveyor assembly using V-belt and pulleys. The electrical circuit consisted of a voltmeter, an ampere meter and an energy meter to measure the energy consumption, Plate 3.8. The motor was mounted on a base frame. A driving pulley of 100 mm diameter was mounted on the motor shaft. The conveyor speed was varied by using three different driven pulleys of diameter 300, 233.0 and 200.0 mm. The change in size of driven pulleys caused a step variation in the conveyor speed.

The experiment was conducted in the laboratory to determine the power consumption of separating unit at different loads and speed of the conveyor. The loads were placed at different oscillation and power consumption was recorded by using an energy meter. The procedure was repeated for different speeds of conveyor. Three replications of each were taken. Using the volume of material flow of 0.0833 m³ s on the separating unit as determined in section (3.5.4.1) and density of the soil in the field 1500 kgm⁻³, the weight of the onion and soil was found to

be approximately 126.25 kg s⁻¹. Therefore, 130 kg was used in the experiment. The conveyor was run at three levels of speed i.e. 0.9, 1.0 and 1.25 ms⁻¹.

The soil working tool having depth/width ratio greater than 1 is known as narrow tyne and depth/width ratio less than 0.5 is called as blade. In case of onion digger the width of share was taken 1m on the basis of tread width of tractor. Jadhav et al. (1995) reported that the location of onion bulb in vertical plane of the field up to the depth of 70 mm and a share operating at this depth would give a depth/width ratio of 0.07.

Therefore, the digging share could be assumed as a blade. The draft of the share was calculated using the general soil mechanics equation suggested by Hettiarachi et al (1966) for a blade deforming the soil in two dimensions. Six different shapes of digging shares viz. straight, convex, concave, triangular fork, inverted V and V-shaped blade were selected for the soil bin evaluation, (Plate 3.9).

The straight blade was selected as this is simple in construction and common on most of the single and double row elevator diggers. The convex and concave shapes were chosen to represent the shape of the

blade harrows being used in different parts of the country. The triangular fork shape was selected as was expected to cause better penetration and comparatively lower draft (Zelenin, 1950).

DETERMINATION OF POWER CONSUMPTION OF CONVEYING SYSTEM

A 2 hp single-phase AC motor having 1440 rpm was used to drive oscillating conveyor assembly using V-belt and pulleys. The electrical circuit consisted of a voltmeter, an ampere meter and an energy meter to measure the energy consumption, Plate 3.8. The motor was mounted on a base frame. A driving pulley of 100 mm diameter was mounted on the motor shaft. The conveyor speed was varied by using three different driven pulleys of diameter 300, 233.0 and 200.0 mm. The change in size of driven

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Using the volume of material flow of 0.0833 m³ s on the separating unit as determined and density of the soil in the field 1500 kgm⁻³, the weight of the onion and soil was found to be approximately 126.25 kg s⁻¹. Therefore, 130 kg was used in the experiment. The conveyor was run at three levels of speed i.e. 0.9, 1.0 and 1.25.



Fig 1: Separating System

Cleaning System:

The windrower of the developed onion digger was located to the rear of the conveyor and extended near to the surface of the field at the time of digging. The width of the windrower was 60 cm. The windrower raked the onions in row on the field. The windrowed onions were left on the field for sun drying and these could be collected easily.

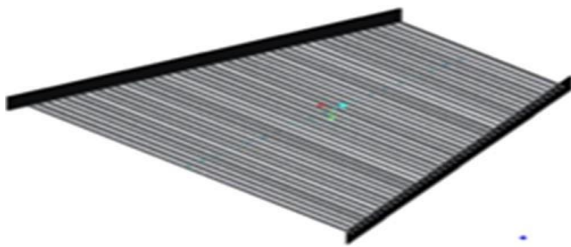


Fig 2: Cleaning System

The main function of conveyor is to convey the onions from digging system to windowing system with separation of onion from soil and other foreign objects. Conveyor unit is used. The system should be such designed that it picks the onion leaves at predetermined height and then passes to the other end of conveying unit.

Collecting System:

Onion bulbs with leaves has to be dropped only from the rear side at the center of the machine, on the ground which will be later collected on the crates for further evaluation by the field team, system should make attempt to avoid any damage to onion

bulb. The leaves to be left along with the onion bulb and no d-trashing (leave cutting) are required.

Onion Collecting Device:

The onion collecting device, equipped with a blade- shaped digging device is a device that supplies the clump of soils, including Welsh onion roots, to the soil separation device by breaking the ridge at the lower front of the harvester. The soil cutting depth for the digging device at the contact surface of the collecting device was set to maintain a height of 5 cm above the lowest point in the ridge, to operate within a distance of 25 cm below the highest point of the ridge, and to break the ridge at a 30° entry angle.

The body of the collecting device had an adjustable inclination angle of $\pm 10^\circ$. In order to minimize the pull load during soil braking, the length of the contact surface of the front digging device was designed with a minimum length of 400 mm.

Power Transmission System:

Harvester is to design the power transmission systems on their own or use any OEM transmission readily available in market, such that maximum speed of the machine on a plain terrain is not more than 15 km/h in top gear. OEM transmissions of

2wheeler, 3 wheelers are acceptable if they meeting the speed criteria. Continuously Variable Transmission (CVT) is also permitted with appropriate shielding. Maximum speed in forward direction should be <15kmph and minimum speed in forward direction should be >0.5 km/ph. Maximum speed in the reverse direction should be set < 5 km/ph. Harvester can have single speed or multi speed gear box and maximum no of allowed forward speeds are 4 and reverse 2.

System can design to use final reduction in the configuration in form of constant velocity joint shaft, chain and sprocket or belt and pulley and can use standard OEM components from market. Lever and shifting mechanism are to be installed at such locations which will not be a hindrance for operator and his safety. All chains and belt drives needs to be protected from coming in direct contact of operator.

Teams can use direct drive, chain or belt drive between engine and Transmission to meet the speed requirement and configure OEM transmission.

All these drive mechanism needs to follow sound engineering practice and shall be appropriately designed. If Cordon (universal) joints are used they must be

shielded radially (360°) with minimum 3mm steel sheet. The maximum deflection angle for universal joints is 10 °.The transmission shall be mounted on the machine structure with sound engineering practice and shall be deigned appropriately. Appropriate care shall be taken for ensuring lubrication to the transmission system of the machine. The machine should be free from any leakage or seepage of fluid.

Engine Specification:

Onion harvester is design by using KOEL CC418 diesel engine. The brief specifications are given below.

- Make/Model: Kirloskar Oil Engines Ltd. (KOEL)/ CC418
- Type: Single Cylinder, Diesel, 418CC, Vertical
- Rating: 8 hp@3000 rpm
- Max Torque:19N.m@2000 rpm
- High Idle: 3300 rpm
- Dry weight: 44 kg
- Size: 470x310x490 cm
- Fuel tank capacity: 3.5L
- Starting method: Rope Start
- Decompression lever

Engine will come following scope of supply

- Base Engine with wire start aid
- Air Cleaner

- Exhaust muffler
- Integrated Fuel tank (3.5 Lit)

The conveyor was driven by P.T.O. of the tractor. The rotating motion of the P.T.O shaft was transmitted to the driving gear through shaft, gear reduction unit and chain sprocket. The rpm of P.T.O shaft was 540 ± 10 . The universal coupling was fitted to the P.T.O flanges and another end to input shaft of 30 mm diameter and 750 mm length of the gear reduction unit.

The shaft was clamped on two bearings and

care was taken on its alignment with the gear reduction input shaft. The gear reduction unit reduced the input speed to $1/3$ and gave the output at right angle to the input. The output shaft was mounted on two bearing and was properly aligned. The other end of this shaft was fitted with a sprocket of 20 teeth which transmitted rotary motion through chain to another sprocket of 30 teeth mounted on the driving gear shaft. An idler was provided in between these two sprockets to increase the contact area and reduce slippage.



Fig 3 Self Propelled Onion Harvester

Cost of Elements:

Engine - 28000

Tyre - 18000

Braking - 12000

Steering - 18000

Mechanism - 30000

Transmission - 69000

Material - 30000

Other - 21100

Miscellaneous - 1000

Lighting and buzzer - 1000

Fire extinguisher - 1500

Total cost - 2, 29,600 (Rupees)

Total operating cost - 217.02

Machine operating cost - 1830.53
(Rs/hector)

Aid To Stop the Engine

Mechanical Aid

In order to ensure the safety of everyone at the competition, all machines built by team must have a provision to cut-off the diesel fuel either by mechanical or electrical means. The mechanical means could be a lever system pulling the fuel shut off or could be a wired system which enables the throttle to move in such orientation that it cuts off the fuel and there by stops the engine. The design of this aid should such that it doesn't compromise with any basic functioning of engine and neither should have any ill effect resulting the damage to engine. The reference mechanical engine

stop could be as below but not limited to this design.

Electrical Aid

The electrical system may include one kill switches, a brake light, and a battery power source. The kill switch if used must deactivate the engine ignition. Kill switch on diesel engines may also stop the air supply immediately. The system must have a spring-actuated air supply cut-off, which may be activated by a Bowden cable. Electrical kill switch if used.

CONCLUSION

In this research, mechanization of harvesting onions, a process that has traditionally depended on labor, will increase productivity and household income through the development and use of an onion harvester mounted on a tractor. The performance of the newly developed onion harvester was tested in an actual onion cultivation farm. At three different tractor speeds of 5.0 cm/s, 11.4 cm/s, and 15.8 cm/s, we have investigated the operating efficiency, harvest rate, damage rate, and residual soil, in order to test the harvesting performance of the onion harvester. The harvest rate was 100% regardless of the speed of the tractor that represents outstanding results. Therefore, when the working speed increases, the

efficiency of harvesting onions will also increase. From the elicited results at the three different working speeds, the damage rate of harvested onions seems to increase proportionately from 4.55% to 6.53% and to 11.29%. The residual soil on harvested onions was 0.24% of the total weight of the onions indicative of the high performance of the harvester in removing soil.

Therefore, based on this study, the newly developed onion harvester will allow the mechanization of the harvest operation that currently requires a substantial amount of labor, thereby contributing to improved conditions in our onion cultivation farms. The soil load on the harvester is comes to be 1.35 N/cm^2 for the speed of 3 km/h. The movement of soil in relation to the path, the discharge volume of the soil mass was observed to be $0.023 \text{ m}^3/\text{sec}$. The soil working capacity of onion harvester is estimated to be 104 ton/h. The PTO power requirement of the harvester for the working speed of 3.0 km/h was estimated in the range of 11 to 13 hp. Bending moment of blade and onion harvester for the load was not taking. Hence for this capacity and discharge safely onion crop harvester. Forces act on implement for this power safely and 3km/h speed was vertical and horizontal safe working.

FUTURE SCOPE

We are planning to mobilize our proposed vehicle for one handed (handicap) person by touch screen pad.

- We are using pinion mechanism.
- Automatic seed sowing and fertilizers sprayers with the help of IOT
- Driverless vehicle
- We can implement this system for multi-purpose like to dig out potato, onion, ging

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