

Onion harvester with topping unit

A complete harvesting machine for onion

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Onion harvesting is one of the main important agriculture operation. It involves topping of onion leaves up to its neck, digging, soil separation, windrowing and collection. The manual method of onion harvesting involves pulling out plants from the soil or digging with locally available khurpa; then, removal of onion leaves requires a high labour force of nearly about 200-280 man-h per ha, costing about ₹4200, and it is a tedious job resulting in fatigue and drudgery to workers. Further, the time available for harvesting onion during peak season is limited, causing high labour demand and cost. In addition, the late and early harvesting of onion also effect the storage life. Thus, harvesting onion within a specified time suitable for market needs is the most important factor in onion harvesting. Hence, an onion digger with a topping unit is a machine that harvests onion suitable to market needs in a single pass with a saving of cost to the tune of 57.09% over the conventional harvesting method.

Keywords: Labour cost, Onion digger, Onion harvesting, Shelf life, Specified time, Topping unit

THE onion harvesting involves four main important operations viz. topping (removal of leaves from the bulb), digging (unearthing of onions), soil-separation (separation of onion from soil and other foreign materials) and windrowing (placing of cleaned onion in a row). Generally, onion harvesting has a small window of about 20-25 days of harvesting period. Otherwise, early and late harvesting of onions affects the quality, perishability and shelf life. During this peak period, the availability of labour is difficult and involves high operational costs. Further, the complete harvesting of onion need to be done within stipulated time for better quality, otherwise it causes rot formation which ultimately effect the storage quality of onion. The traditional manual methods of harvesting are costly, time-consuming and tedious, resulting in lot of biomechanical stresses to operators. The existing and available harvester can only perform either digging operator or digging and soil separation. To

get onion topping, digging, soil separation and windrowing of onion in a single pass need for market needs to be addressed. Thus, to address this issue, an onion digger with a topping unit was developed at Govind Ballabh Pant University of Agriculture & Technology (GBPUA&T) at the Departmental workshop of Farm Machinery and Power Engineering Department. A brief description of the developed machine is shown in Table 1 and the stationary and operation of the developed machine under actual field conditions is shown in Fig. 1. The developed onion digger with topping unit has a unique solution for farmers to harvest onion completely when the neck of onion begins to fall, in a single pass suitable for market needs. This machine can perform four operations viz. topping, digging, soil separation, and windrowing of onions. This machine caters to the residual problems linked with the topping and digging of onions.

Working principle of onion digger with topping unit

As the machine moves forward, the topping unit removes onion leaves ahead of the digging unit. When the digging unit enters the soil, the topping unit aligns with the soil surface and trims the onion leaves. Subsequently, the digging unit unearths the topped onion bulbs. These uprooted bulbs are then conveyed to the soil separation unit, where onions and soil are effectively separated. Finally, the cleaned onion bulbs are discharged at the rear of the machine by the windrowing unit.

The developed machine efficiently de-tops the onion leaves and subsequently digs the de-topped bulbs with an effective width of 750 and 650 mm respectively. It achieves a theoretical field capacity and field efficiency of 0.20 ha/h and 88.50% when machine is operating at a travel speed of 3 km/h. With the introduction of these machines, the productivity and yield of onions can be enhanced.



Fig.1. (a) Developed onion harvester with topping unit, (b) working under actual field conditions.

Table 1. Specifications of onion digger with topping unit

Particular	Specifications
Overall dimensions of machine (L×W×H), mm	1200 × 1050 × 800
Weight of machine, kg	130
Power requirement, hp	15-30
Material of construction	Mild steel
Width of topping and digging unit, mm	750 and 650
Field capacity (ha/h) and efficiency (%) of machine	0.20, 88.50
Operating speed, km/h	3

Traditional (Manual method of onion harvesting)

The traditional manual method of onion harvesting involves pulling out plants by hand if the soil isn't too hard. If the soil is hard, a tool called '*khrupe*' is used to dug out the crop. This process requires about 185 man-hours per hectare, accounting for 21.4% of the total cultivation cost. Then the plucked onion plants are field cured (field drying). After field curing, the onion tops are removed by hand or hand shears, which consumed about 12.5

man-hours per tonne making up 40% of the labour needed for the entire cultivation process. Successful manual harvesting depends on available labour and favourable weather conditions. However, adverse weather conditions, during field curing in summer, the outer scale of onion blisters and during winter also it is difficult.

Existing method of onion harvester

The various types of onion diggers have been developed across different parts of the country having

different types of digging blades, and different mechanisms for soil separations. These harvesters can be front or rear-mounted to prime mover. These machines vary in function; some only unearth onion bulbs, while others handle unearthing and soil separation. However, none of the existing onion harvester addresses topping onion bulbs. This step still requires labour for topping and also onion collection. The process flow chart of different methods of onion harvesting (manual, mechanical and developed machine) is shown in Fig. 2.

Developed onion harvester with topping unit

The topping unit of the developed machine consists of a standard cutter bar with a 750 mm width of topping; this arrangement was done with 76.2 mm stroke lengths of serrated cutter bar blades and a ledger plate arrangement for onion topping. The digging unit consist of a V-shaped blade with a width of 0.65 m to dig the crop from the soil. The blade was positioned 15° rake angle for the unearthing of onion and also had a provision for adjustment for different rake angles to operate at different depths of operations. Both sides of the digging blade, a 2 mm thick flat, were welded so that no slide or fall of the dug onions on outside the digging blade and move

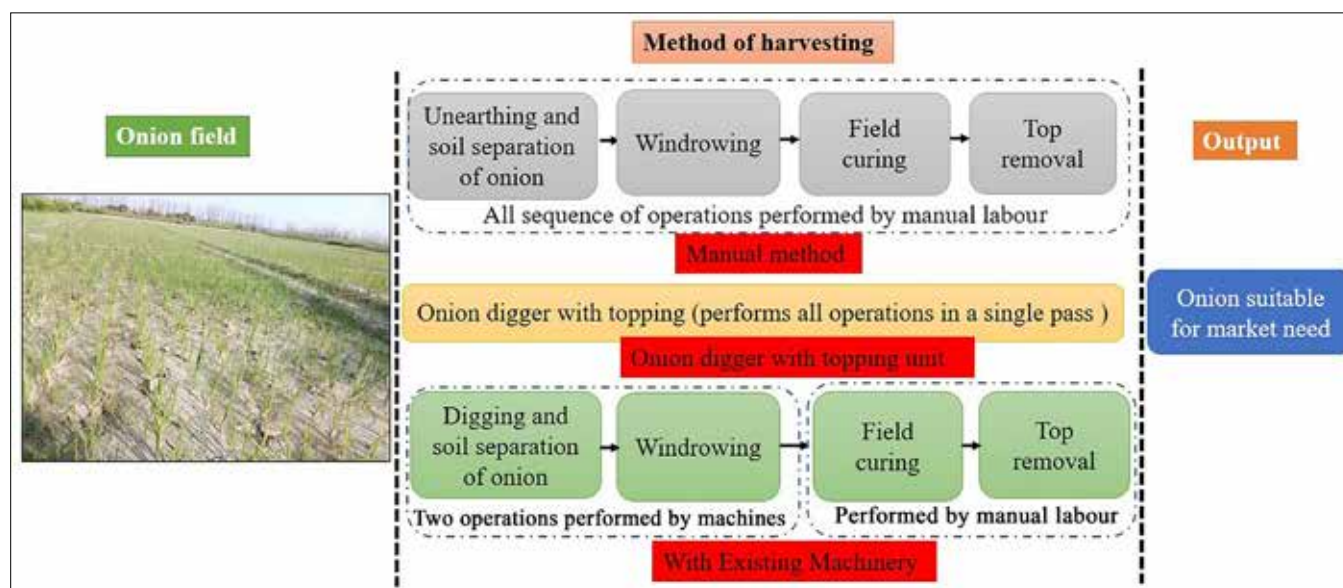


Fig. 2. Process flow chart of different types of onion harvesting methods.

on the soil separation unit. The soil separation unit mainly consists of passive rollers, MS flats, pulleys and belts. The soil separation unit had a rectangular sieve-type arrangement and rotated with the help of a rayon endless belt on passive rollers in the opposite direction of travel to move onion rearward of machine; on the belt, the flats were welded in such a way to allow the onion to pass in the gap between belt, and onions move on the belt at the end. The soil separation unit has 550 mm width and 700 mm length, was made and provided with a 15° slope and also had a provision to change the slope of the conveyor to operate at varying conditions. The windrowing unit consists of two parallel sheets welded after the soil separation unit to eject the cleaned onions after the soil separation in a row to collect them easily. The power transmission system consists of gearbox, different types of cross and flat belts to transmit power to the soil separation and topping unit with a desired speed ratios. The frame of the machine had a provision for mounting the topping unit, digging unit, soil separation unit, windrowing unit and power transmission unit. It also had a three-point hitch to connect it to the tractor, and it was made of mild steel angle iron of 40×40 mm size.

Merits of developed onion digger with topping unit

The developed machine can perform harvesting operations in other root crops (potato, garlic and carrot) with no or other little modifications. The cut, slices and bruises during de-topping, digging, and conveying mechanisms were minimal. The developed machine can perform topping, digging, soil separation and windrowing of onions suitable for market needs in a single pass. The digging efficiency, damage percentage, and topping efficiency with the developed machine at optimum operating parameters are 94.55%, 5.10% and 80.10%, respectively. The effective field capacity of the machine at 3.0 km/h was 0.20 ha/h,

with a field efficiency of 88.50%. The break-even point of the machine is 94.29 h/annum, with a payback period of 0.67 years.

Cost analysis of manual and mechanical methods of onion harvesting

The cost and input energy requirement of tractor-operated onion digger with a topping unit were calculated and compared with conventional manual method. The cost of operation of onion digger with topping unit was calculated using a straight line method based on the initial cost of the machine, ₹27500, with a salvage value of 10% of the initial cost. The life and annual use of the machine were assumed as 10 years and 250 hours respectively. Then, fixed cost (depreciation, interest, insurance and taxes) and variable cost (repair and maintenance, fuel consumption, oil and operator wages) were calculated and combining them the total operating cost was calculated as ₹291.77/h. Then, the total operating cost (including the machine's field capacity) was found as ₹1716.29/ha. In traditional manual methods of harvesting, in a plot, only manual labour was involved for harvesting, topping, and collection of onion and it was found as ₹4000/ha. The saving in cost of operation with onion digger with a topping unit is 57.09% over the traditional method. Considering 25% overhead charges and profit in the machine's operation cost, the machine's break-even point and payback period were calculated and found as 16.03 ha per annum, a 0.67 year payback period respectively.

Input energy requirement in manual and mechanical methods of onion harvesting

Two farms were selected; one group was made on which only manual energy was used. The second group was made on which mechanical-cum-manual methods of energy were used. In case of the manual method, only manual labour was assigned; in case of the mechanical method of onion harvesting (the developed machine, i.e. onion digger with the topping

unit) was used, which will perform all combined operations (topping, digging, soil separation and windrowing in a single pass), after machine operation in mechanical method manual labour was assigned for only collection of onions. Based on the above two practices, the time consumed in each method was recorded and converted into energy using standard energy equivalents. The result of the study showed that the average total input energy in manual and mechanical methods of onion harvesting are 1381.37 and 1022.07 MJ/ha, respectively.

In the manual method of onion harvesting, the total energy input was direct renewable energy. The total average nonrenewable energy input in mechanical method of onion harvesting was 935.37 MJ/ha, which accounts for the highest proportion of total energy input in mechanical onion harvesting, reaching 91.51%, with energy input from diesel energy alone, 84.27% contribution followed by 7.22% machinery energy of the total input energy requirement. In the mechanical method of onion harvesting, the total average renewable method was 85.51 MJ/ha. In the case of the manual method of onion harvesting, the input energy used was direct renewable energy, which was 1381.37 MJ/ha.

SUMMARY

Onion digger with cutter bar topping unit is an innovative machine for harvesting onion bulbs. It has the potential to harvest onions suitable for market needs in a single pass, with additional involvement of labour force. This can be used for various soils and in other root crops with little or no modification. The developed machine performance was satisfactory under actual field conditions. It is a reliable solution, as cost and input requirement saving of 57.09% and 26% respectively, over the conventional manual method of onion harvesting.

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