Design and Development of Onion Harvester

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Abstract

We did study on onion harvesting with machinery in which we found that some researcher performed customer satisfaction portfolio analysis with farmers who brought onion harvester. They also perform conjoint analysis in which they assess farmer's preferences for simulated concepts to improve harvester based on like and dislike. This study helps in improving or developing onion harvester. For calculation purpose we took result of various experiment conducted on laboratory soil bin. There are three possible ways to harvest onion.

Keywords: Onion harvester, Digging share, conveyor, farmers satisfaction

1. Introduction

India has main role in vegetable production starting from 28.36 million tonnes in 1969-70 to 72.83 million tonnes in 1997-98. The present vegetable production in India is 113.5 million tonnes in an area
7.2 million hectare with an average productivity of 15.7 t/ha. 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 crop grown in India from long times. The area under onion is about 7 % of total area under vegetables in the country. To get the production of onion more effectively change in traditional way of producing onion, we must use developed harvester. This paper is about to study of development in onion harvester and its components.

Three possible ways to harvest onion which are,

1. Lift the untopped onions with an elevatordigger mechanism similar to the ones used for potatoes; transport in bulk to a drier and remove the dry tops with a Bruner topper.
2. To reduce the amount of unwanted leafy material kill the tops by spraying with a desiccant or use a potato haulm pulverizer to effect partal topping; then lift, dry and top as before.
3. Lift and top the onions in one operation with a top-lifting harvester.[1]

2. Overview of tropical tuber crops harvesters

a) Welsh onion harvester (kobashi industries)

Welsh onion harvesters are commonly used for labour-saving purposes. This harvester is a selfpropelled ride-on machine that can dig up Welsh onions grown in a ridged field and collect them to a platform at the rear of the harvester. It was originally put into practical use by a research consortium comprising Dr K.Tsuga, Kobashi Kogyo Co., Ltd., and others in the Urgent Research & development of Agricultural Machinery project, implemented by the Bio-oriented Technology Research Advancement Institution (BRAIN, formerly known as the Institute of Agricultural Machinery) in 1998.[1]

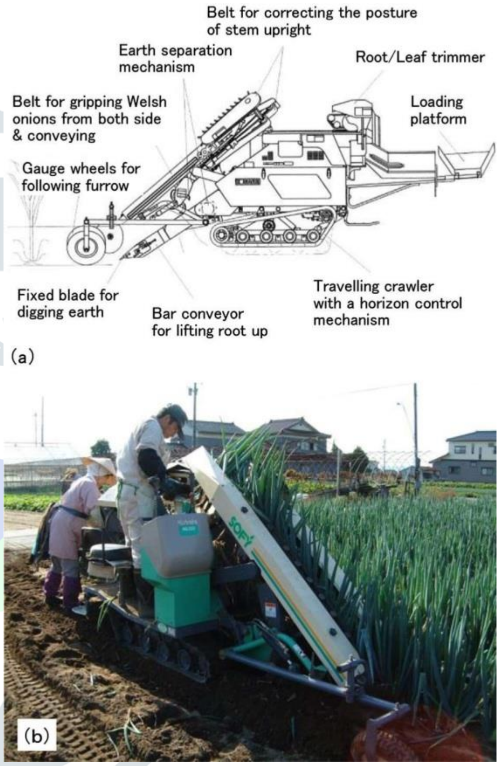


Figure 1 A Welsh onion harvester: (a) schematic diagram and (b) harvesting operation scenery (two operators).[2]

A Welsh onion harvester consists of a 4.6- kW gasoline engine, a traveling crawler, a digging portion comprised of a fixed blade and a bar conveyor, a transfer portion that grips and conveys Welsh onions using belts, an earth separation mechanism including rotors, a loading platform that aligns and collects up to 100 kg of Welsh onions, and an optional root/leaf trimming mechanism. The weight of the harvester is 717 kg. The harvester has a horizon control mechanism that allows for constant operation in a horizontal position. Gauge wheels on both sides of the front of harvester hold the ridge and allow for automatic travel during digging. One of the major challenges in the development of Welsh onion harvesters was to design an earth separation mechanism to dig up the Welsh onions with soil on their roots, remove the soil and transfer them to a tray. operating efficiency of a conventional system for harvesting, binding and conveying, at 70m2 per hour (with one operator) and 210m2 per hour (with two operators). [1]

b) Top-lifting onion harvester

Figure 2 single row, top-lifting onion harvester[1]

The harvester consists of three main components lifting belt, toppingmechanism, outloading conveyor are works on P.T.O. shaft of tractor[1]

3. Farmer's review on welsh onion harvester

By the analysis on important attributes e.g. function, price, design and other factors that determine the value of a product, gives optimum concept about product. In this way analysis make it possible that how much customers like or dislike product. From actual condition survey of who brought and use Welsh onion harvesters conducted at 75 farms in China.

3.1. Farmer's satisfaction survey[2]:

Highest satisfaction working with harvester was-

a) Labour saving effect: By comparing before and after adoption 37man hours saved on average, average number of operators required fell from 3.3 to 2.4 (about 56% manpower reduced) per 1000 □
b) Reduction in production cost: As labour reduced cost required reduced according to survey labour costs were reduced by 412,300 yen (2,67,899 inr) per year on average after purchase harvester.
c) working efficiency.
d) Ease of transportation.
e) Digging performance of the fixed blade. Highest

degree of dissatisfaction were:-

a) Purchase price.
b) Washing and cleaning up.
c) Price of replacement parts.
d) Maintenance.

3.2. Farmers' preferences survey[2]

Farmer's preference survey helps in upgrade the product. This survey also conducted in those farms where satisfaction survey who had purchased Welsh onion harvester and result shows that machine size and efficiency had greatest average importance than other for upgrade. Farmers' preference for smaller machine is more, a better cleaning mechanism, to obtain return on investment affordable prize is most preferable.

a) Machine size: smaller and lighter\than present harvester
b) Soil separation method: new cleaning mechanism (air pressure or water pressure system)
c) Loading method after digging: new conveyor system (corresponding to drying on ground)

4. Design of fixed blade (Digging share):

4.1. Properties of soil at onion harvest:

soil parameters play important role in designing the onion digger. The following soil parameters were observed in the onion plot before the harvesting, [7]

4.2. Bulk density of soil:

Bulk density kit is used for determine bulk density of soil. A core sampler having 50 mm diameter and 300 mm length, marked at each 10 mm interval along its length, was used for taking the soil sample. Initially it was inserted into the soil up to 50 mm only and the soil collected in it was removed immediately as the first sample. Then again the same sampler was inserted into the soil at the same place up to 100 mm depth so as to collect the soil of next 50 mm depth.
Samples were weighed and kept in the oven at 105±50 C for 24 hours. The weight of dry soil was recorded and bulk density on dry weight basis was calculated by using the following relationship

$$\square = \frac{\square}{\square}$$

ρ = Bulk density of soil, g cm -3 γ = Bulk density of soil, kg m -3
M = Weight of dry soil, g
V = Volume of core sampler, cm3 [7]

4.3. Cohesion and angle of internal friction:

In-situ direct shear test apparatus is use to measure shear strength of soil under onion crop. The shear box was pressed into the soil to depth of 15 mm. The shear force was read from the dial gauge fitted inside the probing ring. The soil cohesion and angle of internal friction were determined by Coulomb's equation.

$$\square = C + \square \tan\emptyset$$

Where,

□ = Shear stress

C = Cohesion

□ = Normal stress Ø = Angle of internal friction

4.4. Angle of soil metal friction:

Sliding friction δ which is measurement made on dynamic system, measured by block of soil kept on inclined mild steel plate and angle of inclination increase gradually and angle is recorded when slip occur.

□ = tan □

Where,
□ = Coefficient of friction
□ = Angle of soil- metal friction

4.5. Functional requirement of digger:

i. The onion damage in terms of cut, crush, sliced and bruised tubers should be as low as possible.
ii. The damage to the leaves (tops) should be minimum.
iii. The onion should be dug up from the field in such a way that the minimum volume of soil is removed without causing any damage to the bulbs.
iv. It should have less number of wearing parts.
v. It should be simple in design and construction and efficient in digging onions

4.6. Determination of draft on digging share:

The draft of the share was calculated using the general soil mechanics equation suggested by Hettiarachi et al for a blade deforming the soil in two dimensions

□ = □□ □ + □□ □ + □ □ □+ □□ □

Where,

□ = Passive resistance of the soil acting at an angle of soil metal friction with the normal to interface, kg per meter width □ = Bulk density of soil, kg □

□ = Depth of operation, m

C = Cohesion of soil, kg □

□ = Soil-interaction adhesion, kg □ □ = Surcharge pressure on soil from surface above the failure plan, kg □

□ , □ , □ and □ are the dimensionless N-factors [3]

For determination of the draft the following assumptions were made [3]:

a) Soil is homogeneous and isotropic
b) Average bulk density of soil is taken as 1.45g □□
c) Soil is in friable range of moisture content with cohesion (c) to 0.07kg □□,angle of internal friction (Φ) equal to 25o and angle of soil metal friction (δ) equal to 20 for bulk density of 1.45 g □□ .
d) The adhesion of the soil can be taken as zero i.e. □ = 0 assuming soil-metal
e) friction zero as soil scouring over the blade.
f) The surcharge in front of the soil above the soil failure zone is negligible i.e. q = 0.
g) The usual variations in rake angle of the digging share have been reported between 15 to 20 by many researchers. A rake angle of 20 gave minimum draft and maximum upward force for a simple Tyne as reported by Payne (1956). This was further substantiated by Osman (1964) in the case of a blade. Therefore, the rake angle of the share was assumed as 25o for determination of draft. Based on the above assumption equation can be reduced as follows

□ = □□ □ + □□ □

□ = 1.65 when δ=0

□ = 1.83 when δ=20

□ = 1.72 when δ=0

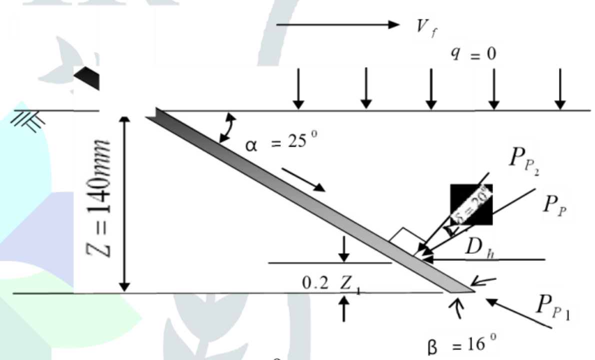
□ = 1.68 when δ= 20

□ = 1450 x 0.12 x 1.83 + 710 x 0.1 x 1.68

=145.82 kg □

Therefore, □ for an effective width of cut 1m of blade = 145.82 kg

And components of □ is □ and □ is given by



□ = 145.82 $cos70^{0}$ = 49.87 kg

□ = 127.15 cos20 = 137.03 kg[4]

The obtained value of □ and □ will determine the bending moment of the digger blade.

□ is perpendicular force to the plane of digger shear and which is responsible for bending of digger. Using □ we can calculate thickness of digger shear. □ is parallel force to plane of digger shear which induce direct stress in the share. Bernacki (1972) assumed that the average soil resistance of shovel acts at a distance of 0.2z1 measured from the cutting edge.

160 - 33.13 = 126.87 mm = 12.69 cm

Therefore, the bending moment due to □will be
B.M= 137.03x12.69=1738.91 Kg-cm

$$□ = \frac{□.□}{\frac{1}{6}□□}$$

Where

B.M. = Bending moment, kg-cm

b =Width of blade at the point of mounting,cm t =Thickness of the plate for share, cm and direct

stress (□) due to Pp1

$$□ = \frac{□}{□□}$$

Total stress (σ) =□ +□ By simply calculations t = 9.963mm ≈ 10mm

5. Data for design of conveyor:

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 m^3/sec.[4]

6. Conclusion:

1. Farmers' high satisfaction was working efficiency and welsh onion harvester achieved it.
2. Because prize had low satisfaction it is necessary to improve this factor.
3. Farmers had dissatisfaction on maintenance.
4. Farmers had satisfied on digging performance of the fixed blade.
5. The thickness for 1m width and 1.2m depth is calculated app.10mm
6. Soil load and discharge volume are1.35N/□□ ,0.023 □ /□□□ respectively
7. Thecost of mechanical harvesting, collection and manual harvesting were also calculated. It was found that there was 58 per cent and 49 per cent saving of labor and cost, respectively

These results suggest possible directions for development and improvement of agricultural machinery, and their order of priority.

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