Journal of Positive School Psychology
2022, Vol. 6, No. 3, 7095–7101

Investment Cost Analysis of the Developed Hand Tractor Driven Onion Harvester

Rosalinda L. Abad [1], Hipolito C. Buccat [2], Zion Jemillinium S. Tam-awen [3], Jessica A. Pagaduan [4]

[1] Project Leader, Institute of Agricultural and Biosystems Engineering, Don Mariano Marcos Memorial State University, North La Union Campus, Bacnotan, La Union, Philippines.
[2] Peoject Staff, Institute of Agricultural and Biosystems Engineering, Don Mariano Marcos Memorial State University, North La Union Campus, Bacnotan, La Union, Philippines.
[3] Science Research Specialist II, Institute of Agricultural and Biosystems Engineering, Don Mariano Marcos Memorial State University, North La Union Campus, Bacnotan, La Union, Philippines.
[4] Project Assistant I, Institute of Agricultural and Biosystems Engineering, Don Mariano Marcos Memorial State University, North La Union Campus, Bacnotan, La Union, Philippines.
Email: [1] rabad@dmmmsu.edu.ph, [2] hcbuccat@dmmmsu.edu.ph, [3] ztamawen@yahoo.com, [4] jessicapgdn@gmail.com

Abstract

In the Philippines, manual harvesting of onion is still a practice. For this reason, an onion harvester that is adaptable to local field conditions developed. However, the technical design must be with economic viability to guide the farmers in making accurate decisions for investment. Thus, the study of calculating the break-even point (BEP), payback period (PP), benefit/cost ratio (BCR), and comparing the cost of manual and mechanical harvesting conceptualized. Based on the results, the recovery of investment cost or PP is 2.03 years; the break-even point is at 4.86 ha/yr, and the BCR is feasible at 2.19. When comparing mechanical and manual harvesting, the former requires a labor of 10 man-day/ha and a cost of PhP4,419.50/ha. The latter of 23 man-day/ha and PhP8,156.95/ha, respectively. The reduction of 13man-day/ha and PhP3,737.45/ha implies a significant advantage when using the machine. Thus, utilizing the cost-effective onion harvester could increase the profitability and productivity of farmers.

Index Terms— Agricultural machinery, hand tractor, investment analysis, onion harvester

This research is funded by the Department of Science and Technology - Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development (DOST-PCAARRD).

I. INTRODUCTION

Investments in agricultural machinery increase the farm power supply; thereby, more tasks are timely completed, and more areas are cultivated. Purposely, to produce larger quantities of crops while conserving natural resources. However, investing in agricultural machinery cannot ensure such results without additional measures. It requires a minimum condition to adhere to and ensure efficient

mechanization. These are suitability to small farms, simple design and technology, and affordability [6]. In the Philippines, where farmers have average landholdings of 1.29 hectares/farmer [9], it needs to prioritize agricultural machinery suited to small farms for sustainable utilization and productivity.

The mechanization level in the country is low at 1.23 hp/ha [3]. Increasing this current level of mechanization does not necessarily mean costly investments in tractors in other machinery [7]. It must be on providing the needs of farmers effectively and efficiently; more importantly, the drudgery reduction associated with manual labor is the key element of sustainable mechanization accessing appropriate forms of farm power. This goal is anchored to the development of small machines/equipment that is affordable and adaptable to local field conditions.

The affordability of machines should not only be limited to the farmer's purchasing ability. Farmers also need to be educated as investment decisions are one of the most significant farm management decisions they have to take [2]. Purchasing a piece of machinery requires precise estimation of the associated costs (annual ownership and operating cost) [8]. Making a smart decision can reduce machinery costs as much as PhP6,898.70/ha [5]. This significant decrease in machinery cost to small farmers in the Philippines could salvage profit and inaccurate investments. Thus, prioritizing machinery development covering investment analysis is the key for effective machinery management and sustainable machinery utilization [1].

The developed onion harvester is a hand tractor implement designed to adapt to the local field conditions. Specifically, to sustainably utilize the locally designed hand tractors not just for land preparation and transportation but also for other operations on the farm. Thereby, reducing the cost of investing in another power source to operate the machine. A farmer with high farm power beyond the requirement diminishes the profit returns and prolongs the investment recovery. Hence, to assist local farmers in investing in this developed onion harvester, this study of investment cost analysis was conceptualized. Specifically, to calculate the investment cost parameters of break-even point, payback period, and benefit/cost ratio. And to compare the cost of manual and mechanical harvesting using the hand tractor-driven onion harvester. Disclosing this information to farmers helps make smart decisions in selecting the accurate size of the machinery. Purposely, to considerably decrease the farming expenditures, thereby realizing more income and increased quality of work.

II. MATERIALS AND METHODS

A. Research Design

This study adopted the descriptive research design to attain the specific practices in the local onion industry, particularly in the harvesting operation. It focused on the cost comparison using manual and the developed onion harvester. In realizing the impact of the study, the calculations of economic measures adapted the equations based on standards.

B. Investment Cost Analysis

The three (3) parameters of investment analysis were used to determine the economic feasibility of the machine. These are the break-even point analysis, payback period, and benefit/cost ratio.

The investment cost of the hand tractor was not considered in the calculation. However, the tractor cost or the cost of operation was calculated as variable cost; since the onion harvester is driven by the hand tractor.

C. Break-Even Point (BEP) Analysis

The BEP analysis shows the point where there is enough revenue to pay all associated cost. It is the intersection point of total gross revenue and total cost. The BEP is a point at which neither profit nor loss is made and known. Equations (1) through (9) were used for the calculation of BEP.

$$IC = COM + L \quad (1)$$

$$SV = 10\%IC \quad (2)$$

$$D = \frac{IC - SV}{n} \quad (3)$$

$$FC = D + I + TIS \quad (4)$$

$$VC = Cp + Cl + RM + Clu + Ct \quad (5)$$

$$THC = FC + VC \quad (6)$$

$$HC = \frac{VC}{C}' T \quad (7)$$

$$BEP = \frac{FC}{Cr} - Bc \quad (8)$$

$$ANI = C' T' (Cr - Tc) \quad (9)$$

Where: IC - investment cost of the machine, PhP;
COM - total cost of the materials;
L - cost of labor of fabrication, PhP;
SV - salvage value of investment cost, PhP
D - depreciation cost, PhP/yr;
n - life span, years;
FC - annual fixed cost, PhP/yr;
VC- variable cost, PhP/yr;
TIS - taxes, insurance, and shelter, PhP/yr;
I- interest on investment, PhP/yr;
Cp - cost of fuel, PhP/yr;
Cl - cost of labor, PhP/yr;
Clu - cost of lubrication, PhP/yr;
Ct - cost of using the tractor, PhP/yr;
RM - repair and maintenance cost, PhP/yr;
THC - total onion harvesting cost, PhP/ha;
C - harvesting capacity of the machine, ha/hr;
HC- onion harvesting cost, PhP/ha;
T - annual operating time, hrs/yr;
Cr - custom rate, Php/ha;
BEP - total number of hectares the onion harvester will work to recover the IC, ha
ANI - annual net income, PhP/yr; and
Tc - annual cost, PhP/yr

D. Payback Period (PP)

The PP points out the duration it will recover the investment or the duration in years where cash outflows and inflows are just equal. It is also known as simple payout method that concerns on the recovery of investments not on profitability. Equation (10) was used to calculate payback period.

$$PP = IC / ANI \quad (10)$$

Where: PP - payback period, years

E. Benefit/Cost Ratio (BCR) Method

The BCR is the ratio of discounted benefits versus all associated costs. Project proponents use this standard procedure for making smart decisions on investing in a project. If the BCR > 1.0, the project is feasible, therefore investment is viable. However, if BCR < 1.0, the project is not feasible, the investment is not viable or recommendable. Equations (11) through (13) were used to calculate BCR.

$$PWB = AGI(P/A, I\%, N) \quad (11)$$

$$PWC = ATC(P/A, I\%, N) - SV(P/F, I\%, N) \quad (12)$$

$$BCR = PWB / (PWC + IC) \quad (13)$$

Where: PWB - present worth benefits, PhP;
AGI - annual gross income, PhP/yr;
$I\%$ - interest rate in investment cost, 12%;
N - life span of the project, years;
PWC - present worth costs, PhP; and
ATC - annual total costs, PhP

F. Cost Comparison of Manual Vs. Mechanical Harvesting

The manual harvesting of onion in area/time or ha/hr is actual data gathered during the performance test of the machine. To eliminate bias in data collection, two (2) onion farmers implemented the manual harvesting of onion, and two (2) onion farmers operated the onion harvester. The onions in the 24 experimental plots (10m x 0.5 m/plot) are tapped for both harvesting methods before the start of data collection. The tapping/cutting of onion leaves is on the local market standards.

The average time for manual harvesting was calculated and converted at PhP44.33/hr, the allowable wage for agricultural woks [10]. The fuel consumption of the machine is calculated using the current price of PhP51.70/li [4]. The cost of mechanical harvesting was calculated

using the data collected for harvesting capacity and fuel consumption.

III. RESULTS AND DISCUSSION

A. Mechanical Harvesting Using the Onion Harvester

The onion harvester shown in Figure 1 is a hand tractor implement capable of digging, lifting, cleaning, and collecting onion bulbs in one operation. It is a single row harvester that can be hitched to a locally designed hand tractor with a single forward speed and has no reverse. The parts were made of locally available materials and fabricated by a local manufacturer. It has five (5) main assemblies: the mainframe, digger blade, soil-onion separation device, power transmission system, and discharge cart.

The onion harvester technical parameters involved in the calculation are the harvesting capacity of 0.03 ha/hr or 300 m^2/hr and the fuel consumption of 1.35 li/hr.

B. Manual Harvesting

The manual harvesting of onion shown in Figure 2 is the pillar for the development of this study. The result showed that the harvesting capacity of human has a mean of 0.0055 ha/hr or 55 m^2/hr shown in Table 1.

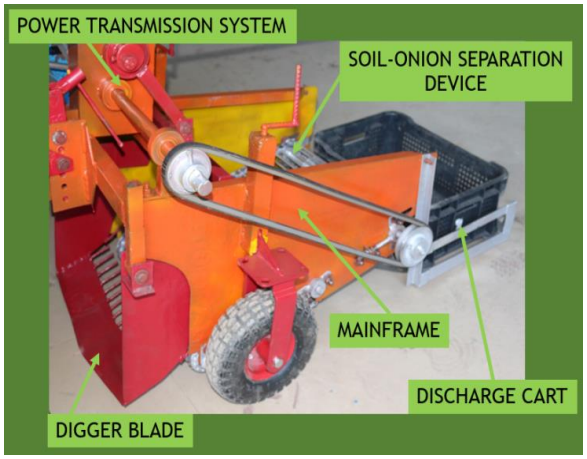

Figure 1. *Developed onion harvester implement for hand tractor*

Figure 2. *Manual harvesting of onion during the machine field performance evaluation*

TABLE 1. *Manual harvesting capacity of human*

Manual Harvesting	Mean of five (5) replications
Farmer 1 (ha/hr)	0.0050
Farmer 2 (ha/hr)	0.0060
Mean	0.0055

C. Investment Cost Analysis

The investment analysis employed the calculation of PP, BEP, and BCR in determining whether the machine is cost-effective in harvesting onions. The assumptions used in the calculation are in Table 2. The investment cost of the onion harvester was PhP32,315.00, covering the total cost of material and fabrication. The annual FC calculated was PhP10,825.53/yr. It is the cost incurred for deprecation with a life span of 5 years; interest on investment; and housing, taxes, and insurance. The total annual VC calculated was PhP174.52. It is the summation of the cost incurred for fuel cost at PhP51.70/li; lubricant cost, repair, and maintenance; labor cost at PhP44.33/hr; and tractor cost. The tractor cost of PhP43.20/hr was included as a variable cost since the onion harvester is an implement; it is power-driven dependent on the hand tractor.

The calculation resulted in an annual cost (14) and (15) and yielded Figure 3 and Table 3. The former shows the break-even point curve (ha/yr); the latter shows the summary of investment analysis of using the machine.

$$Cu = (10{,}825.53 / A) + 4{,}419.50 \quad (14)$$

$$AC = 10{,}825.53 + [(A / 0.03)' \ 174.52] \quad (15)$$

TABLE 2:

Assumptions in the investment cost analysis of the onion harvester implement

Particulars	Hand tractor	Onion harvester
Purchase Price, PhP	60,000.00	32,315.00
Salvage value, %	10.00	5.00
Years, n	10.00	5.00
Fuel consumption, li/hr		1.35
Fuel price per liter, PhP/li		51.70
Repair and maintenance, % Php/100 hr	1.20	1.00
Rate of interest, %	20.00	20.00
TIS, %	4.00	4.00
Labor cost, PhP/day		354.65
Annual hours, hr/year	400.00	
Capacity, ha/hr		0.030
A. Fixed Cost Items		
Depreciation	5,400.00	6,139.85
Interest on investment	6,600.00	3,393.08
TIS	2,400.00	1,292.60
Total Annual FC, PhP/yr	14,400.00	10,825.53
B. Variable Costs		
Fuel cost		69.80
Lubricant cost		13.96
Repair and maintenance	7.20	3.23
Labor		44.33
Tractor cost	43.20	
Total VC, PhP/hr	174.52	

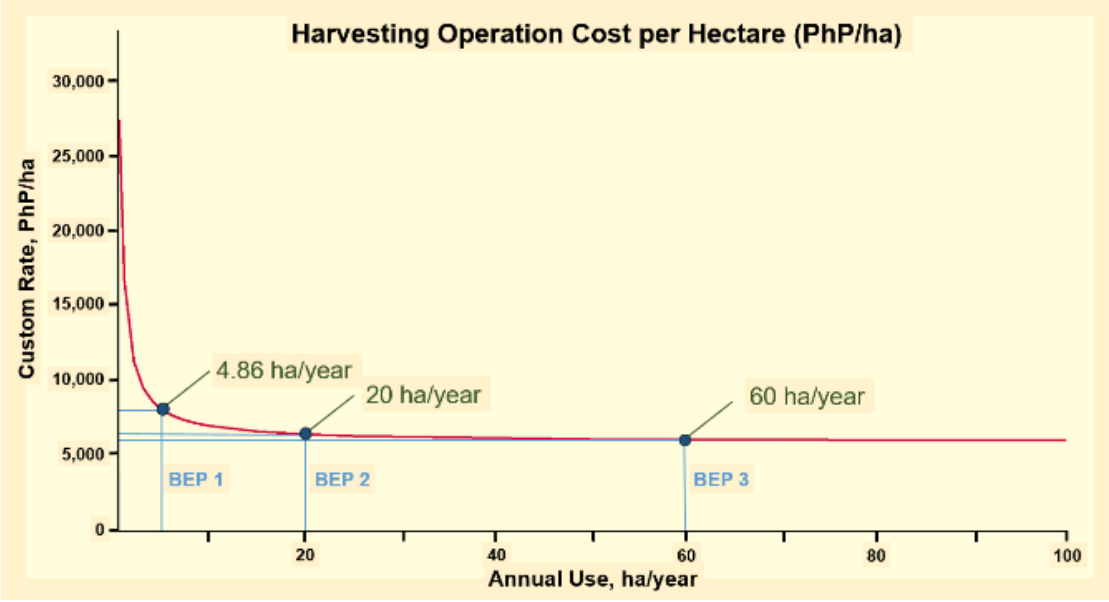

Figure 3. *Onion harvester break-even point cost curve*

TABLE 3. *Summary of investment cost analysis of the onion harvester*

Particulars	Value
Total annual fixed cost, PhP/yr	10,825.53
Total variable cost, Php/yr	174.52
Harvesting cost, PhP/ha	4,419.50
Net income generated, PhP/yr	15,925.18
Break-even point, ha/yr	4.86
Payback period, years	2.03
BCR	2.19

The planting of onion is twice a year. With this, the onion harvester was projected to be in operation for 25 days per cropping season or 400 hours/yr. Calculating using the harvesting capacity of 300 m^2/hr, the computed annual capacity is 12 ha/yr. Also, the total harvesting cost is PhP4,419.50/ha; the payback period is 2.03 years, and the profit income is PhP15,925.18/yr.

The custom rate of the machine is assumed to be equal to the manual harvesting capacity at 0.0055 ha/hr, calculated at PhP8,046.45/ha. This yields to a BEP of 4.86 ha/yr. It signifies that the onion harvester needs to operate at BEP to recover the gross revenue. As the machine harvests beyond the BEP, it will generate profit. If the farmer does not own the required BEP, it is best to adopt custom hiring or renting the onion harvester. However, if a farmer owns or cultivates higher than 4.86ha/yr; it is best to acquire/invest the onion harvester implement.

D. Cost Comparison of Manual and Mechanical Harvesting of Onion

Due to the high labor and cost requirement of manual harvesting operation of 23 man-day/ha and PhP8,156.95/ha; utilizing the developed onion harvester could reduce these requirements. From the results, the onion harvester requires labor and cost of 10man-day/ha and PhP4,419.50/ha, respectively. The reduction of 13 man-day/ha and PhP3,737.45/ha implies a significant increase in profit to farmers. During the peak season of harvest, where labor is scarce, the use of onion harvester could address this problem.

IV. CONCLUSION

The study conceptualized formulating a scientific approach in determining the economic aspect of the developed onion harvester. With the results, the machine is economically viable. It decreases the labor and cost requirement eliminating laborious and costly manual operation. Utilizing the machine could increase productivity and profitability in production. Accelerating policy formulation to develop Philippine Agricultural Engineering Standards [PAES] of onion harvester is encouraged. Also, involvement of the Agricultural Machinery Testing and Evaluation Center [AMTEC] performance tests before commercialization.

ACKNOWLEDGEMENT

The researchers acknowledge the Department of Science and Technology - Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development (DOST-PCAARRD) for supporting the study and above all, to Almighty God for letting His blessings overflow.

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