



## AN INVESTIGATION INTO THE EFFECT OF USING DIFFERENT HARVESTING METHODS ON THE INDICATORS OF POTATO CROP LOSS

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### ABSTRACT

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An experiment was conducted in Nineveh, Iraq. The study evaluates the efficacy of three methods for harvesting potato crops (Semi-Mechanized Harvesting, which includes single-row and two-row harvesting, and manual harvesting). Evaluation through study effects of ways on the undamaged tubers, severely damaged tubers, slightly damaged tubers, qualitative loss, quantitative loss, produced tubers, the time of the harvest process, and harvest costs with the total loss which goes in line with each method). The best performance was obtained for semi-mechanized harvest (2-row harvesters); it recorded the lowest percentage of severely damaged tubers of 0.2 ton. ha<sup>-1</sup> and the highest rate of lifted tubers was 24.6 ton. ha<sup>-1</sup>. The production of the best sample about 25.49 ton. ha<sup>-1</sup> while the highest productivity about 2.24 ha. h<sup>-1</sup>. Moreover, the lowest harvest costs were 4.5\$. ha<sup>-1</sup>, and less time for completion of the harvest process was 0.44 h. ha<sup>-1</sup>. At the same time, the manual harvesting process has recorded a higher percentage of undamaged tubers was 20.76 ton. ha<sup>-1</sup> and a lower percentage of damaged tubers about 3.63 ton. ha<sup>-1</sup>, a lower percentage of quantitative loss of 0.49 ton. ha<sup>-1</sup>, and less loss in total quantity of 877 \$. ha<sup>-1</sup>. Finally, in the manual harvesting process, the farmer needs 45 workers to complete per hectare within an hour.

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## INTRODUCTION

Potato is the largest non-cereal food crop worldwide and ranked as the world's fourth most important food crop after rice, wheat, and maize. Potato is planted in the spring and autumn seasons in Iraq, but the cultivated area and local production do not meet local annual consumption. Therefore, the Iraqi government imported potatoes from other neighboring countries. Any crop's profits can be increased by increasing the cultivated areas, yield quality, or reducing production cost. Among farmers, it has been noticed that harvesting and collecting potatoes without damaging them is essential. Potato tubers are subjected to be cut or damaged during the harvest. It is mostly due to inefficient machine organization and setup, in terms of the depth of extraction or collection speed. Such ineffective harvest will reduce crop quality and quantity, and the profit would be less than supposed. Baio *et al.*, (2004) have stated that the proper selection of agricultural equipment is an important stage in the production process. Arfa, (2007) indicated that the equipment in the harvest season has an important impact on reducing the damage of tubers. Unlike da Cunha *et al.*,

(2011), who found that the cost of semi-mechanized harvesting is more than 49 percent of the cost of mechanized harvest, as well as, Khan *et al.*, (2011), Söğüt and Öztürk (2011) indicated that the number, size, and weight of tubers increase with the delay time of harvest. Sometimes, farmers who have small spaces may tend to harvest potatoes manually or use a lifting machine of one line since there are no developed machines since it is costly, so farmers are not to have it. Therefore, it is preferable to use two-line cultivators to reduce production costs, reduce time, and increase productivity by hectares per hour. In addition, Kumar and Tripathi, (2017) indicated in comparing manual harvesting and semi-mechanized harvesting that the semi-mechanized harvest reduces 75% of workers and 50% of the harvest time. Furthermore, he also showed that one hectare needs (600-700) workers to harvest it.

On the other side, Rani *et al.*, (2019) showed that 54% of costs can be saved when comparing handwork lifting with mechanized ones. AL-Dosary (2016), Kheiry *et al.* (2018), and Arafa (2019) agreed that with the increase of the depth of a hole, the lifted tubers might increase and damaged tubers' percentages decrease. However, it is preferable to find tubers and know the depth they have reached before making the harvest process to organize the machines for work. Finally, it is recommended to apply irrigation before harvest to increase the soil's moisture content, thus reducing the number of damaged tubers (Bentini *et al.*, 2006). The study aims to evaluate the efficacy of three methods for harvesting potato crops (Semi-Mechanized Harvesting, which includes single-row and two-row harvesting, and manual harvesting). Evaluation through study effects of ways on the undamaged tubers, severely damaged tubers, slightly damaged tubers, qualitative loss, quantitative loss, produced tubers, the time of the harvest process, and harvest costs with the total loss which goes in line with each method.

## **MATERIALS AND METHODS**

The experiment was conducted in Mosul/Iraq. The cultivated potato variety was *Arizona*; The distance between planting rows is 77 cm, and one plant to plant spacing is 30 cm. The planting depth is 15 cm, and it was lifted after 150 days of planting. The extraction was carried out by two fortresses produced by Sabz Dasht company, consisting of two rows, the first consisting of two rows with a working width of 150 cm and weight approx. of 697 kg, and the second consisting of one line, a working width of 75 cm, and an approximate weight of 470 kg, while the third method uses a shovel to harvest potatoes by hand.

The field was divided into three sections, each section included the used harvesting method and with three replications. The length of a single transaction is 30 meters. Samples were taken 5 m after the beginning of the harvest row and before end it's for the harvester to reach the required depth 20 meters.

The farmer sold undamaged tubers and slightly damaged tubers at 320 \$ and 200 \$. Consequently, the severed, damaged, and unlifted tubers have not been sold, which leads to a significant loss for the farmer. The experiment was conducted with three replicates, and samples were held through the extraction process. Further, a scale was used to account for the weights of tubers for the studied characteristics, and through mathematical equations, the following values were determined for the studied characteristics:

1- Quantity of traits in the sample (UD, SD, SL, QL) (Seddiq, 2012)

$$\text{Quantity of traits in the sample} = (W / 1000) * (10000) / S / 1000 \dots\dots\dots(1)$$

**Where:**

**W** = The weight of the trait in the sample per (gram)

**S** = The area of the sample

**UD** = undamaged tubers

**SD** = Severe damaged tubers: tubers that were lifted by the machine because the machine was not working below the tuber's presence

**SL** = Slightly damaged tubers: tubers that have been damaged due to their movement on the chain during work.

**QL** = Quantitative loss: tubers that didn't harvest left in the field.

2. Qualitative loss (TD), which is the sum of SD+SL .....(2)

3. lifted tubers (LT) which is the sum of UD+SD+SL .....(3)

4. Production of the ideal sample: is the sum of UD+SD+SL+QL .....(4)

It must be noted that the account of the production of the ideal sample was made after summing the components of the model (UD, SD, SL, QL) and multiplying the sum by 320.

5. The total loss (TL) is the product of subtracting the production of the ideal sample \_ lifted tubers.

6. Costs of the harvest: It is calculated as follows (AL-Tahan *et al.*, 1991)

a. Semi-mechanized harvest costs (\$/ha<sup>-1</sup>)  $SM = A / P \dots\dots\dots(5)$

A = total cost of operating the machine per hour (\$/h<sup>-1</sup>)

P = average of machine productivity per hour (ha/h<sup>-1</sup>)

b. Manual harvesting costs (\$/ha<sup>-1</sup>)  $MH = (N * R) / H \dots\dots\dots(6)$

N = (Number of workers engaged in lifting (h/ha<sup>-1</sup>))

R = worker's wages (\$/day<sup>-1</sup>)

H = Number of hours of daily use (h/day<sup>-1</sup>)

7. Productivity (ha/h<sup>-1</sup>) : It is accounted as follows

Productivity =  $1.6 * V * B * \eta \dots\dots\dots(7)$

V = speed km/h<sup>-1</sup>

B = width in meters

$\eta$  = efficiency

## RESULTS AND DISCUSSION

The results of manual harvesting Table (1) showed that the highest rate of undamaged tubers is 20.76 ton/ha<sup>-1</sup>, and it achieved a profit of 6643 \$/ha<sup>-1</sup>. However, its comparison with 2-row semi-mechanic harvesting gets about 19.81 tons/ha<sup>-1</sup> and the selling price is 6339 \$/ha<sup>-1</sup> while the single row semi-mechanized harvesting gets 17.01 ton/ha<sup>-1</sup> and selling price 5443 \$/ha<sup>-1</sup>. These results happened because there is a lack of a chain conveyor for the tubers compared to the other methods. Further, 2-row Semi-mechanized harvesting has a lower percentage of severely damaged tubers (0.20) ton/ha<sup>-1</sup> compared with the Semi-mechanized harvesting (one row) (0.48) ton/ha<sup>-1</sup> and the Manual lift 1.39 ton/ha<sup>-1</sup>. The main reason behind the lowest percentage of Semi-mechanized harvesting (two rows) is the machine's weight, which makes it work at the depth of specific extraction with less impact on the soil than other methods. and this characteristic was recorded 0 \$/ha<sup>-1</sup>.

The slightly damaged tubers was recorded 5.58, 4.95 and 2.24 ton/ha<sup>-1</sup> for single row and two rows of semi-mechanical harvest, and the manual harvesting, respectively. It because the length of the chain conveyor and the longevity of the

tubers on it is the main reason for the quality of tubers between semi-mechanical harvesting and manual harvesting (Seddiq,2012). The tubers selling prices for semi-mechanical harvesters (single row and two rows) and manual harvesting were about 1,116 \$.ha<sup>-1</sup>, 990 \$.ha<sup>-1</sup> and 448 \$.ha<sup>-1</sup>, respectively.

As a result, Semi-mechanized harvesting (single-row) recorded the highest percentage of quantitative loss (1.21) ton .ha<sup>-1</sup> compared with the Semi-mechanized harvesting (two rows) (0.89) ton .ha<sup>-1</sup> and manual harvest (0.49) ton.ha<sup>-1</sup>. The high percentage of healthy tubers is the main reason for its decrease in the manual method which reduces the number of tubers that were not lifted. However, the percentage of the sale is (0) \$.ha<sup>-1</sup> since the tubers were not lifted and there were tubers under the working line of semi-mechanized harvesters and manual extractions, which negatively affected the farmer's profits in the production process.

Table (1): The relationship between harvesting methods and some field traits.

Harvesting Methods	Traits				
	Traits unit	Undamaged tubers	Severe damaged tubers	Slightly damaged tubers	Quantitative loss
T.R.S.M.H.	Ton. ha <sup>-1</sup>	19.81	0.2	4.95	0.89
	\$. ha <sup>-1</sup>	6339.2	0	990	0
S.R.S.M.H.	Ton. ha <sup>-1</sup>	17.01	0.48	5.58	1.21
	\$. ha <sup>-1</sup>	5443.2	0	1116	0
M.H.	Ton. ha <sup>-1</sup>	20.76	1.39	2.24	0.49
	\$. ha <sup>-1</sup>	6643.2	0	448	0

T.R.S.M.H.= Two rows semi-mechanized harvest.

S.R.S.M.H.= Single-row semi-mechanized harvest.

M.H.= Manual harvest.

It is shown that Manual harvest Table( 2) achieved the best results of qualitative loss, where the lowest value was recorded (3.63) ton.ha<sup>-1</sup> compared with the Semi-mechanized harvesting (two rows) (4.79) ton.ha<sup>-1</sup> and Semi-mechanized harvesting (single-row) (6.06) ton.ha<sup>-1</sup> with a difference of (2.43) ton.ha<sup>-1</sup> with Semi-mechanized harvesting (one line), the main reason is due to the high amount of slightly damaged tubers in the one-line quarry compared to manual harvesting, that negatively affected on the quality of the product, and the selling price of tubers increased from (448) \$.ha<sup>-1</sup> for manual harvest (1116) \$.ha<sup>-1</sup>, semi-mechanized harvest(single-row) with a slight difference (668) \$.ha<sup>-1</sup>.

Furthermore, the data indicates that Semi-mechanized harvest (two rows) has recorded the highest percentage of lifted tubers was (24.60) ton .ha<sup>-1</sup> and the selling price is (7329) \$.ha<sup>-1</sup> compared to manual harvest (24.39) ton.ha<sup>-1</sup> at a selling price (7091) \$.ha<sup>-1</sup> and Semi-mechanized harvest (single-row) (23.07) ton.ha<sup>-1</sup> with a sale price (6559) \$.ha<sup>-1</sup> and a selling difference reached (770) \$.ha<sup>-1</sup> between Semi-mechanized harvest (two rows) and semi-mechanized harvest(single-row).

The table (2) showed that the characteristic of producing the ideal sample has recorded its highest value at Semi-mechanized harvest (two rows) and showed

(25.49) ton. ha<sup>-1</sup> compared with manual harvest (24.90) ton. ha<sup>-1</sup> and Semi-mechanized harvest (single-row) (24.28) ton .ha<sup>-1</sup>. The selling price was at Semi-mechanized harvest (two rows) (8156) \$. ha<sup>-1</sup> and selling price by manual harvesting (7968) \$. ha<sup>-1</sup> and the selling price is Semi-mechanized harvesting (one line) (7769) \$. ha<sup>-1</sup> with a difference (387) \$. ha<sup>-1</sup> among mechanic harvest (one and two rows); this is due to the high percentage of undamaged tubers in a Semi- mechanized harvest (two rows).

Table (2): The relationship between harvesting methods and field traits

Harvesting Methods	Traits			
	Traits unit	Qualitative loss	Lifted tubers	Production of the perfect sample
T.R.S.M.H.	Ton. ha <sup>-1</sup>	4.79	24.6	25.49
	\$. ha <sup>-1</sup>	990	7329.2	8156.8
S.R.S.M.H.	Ton. ha <sup>-1</sup>	6.06	23.07	24.28
	\$. ha <sup>-1</sup>	1116	6559.2	7769.6
M.H.	Ton. ha <sup>-1</sup>	3.63	24.39	24.9
	\$. ha <sup>-1</sup>	448	7091.2	7968

T.R.S.M.H.= Two rows semi-mechanized harvest.

S.R.S.M.H.= Single-row semi-mechanized harvest.

M.H.= Manual harvest.

Table (3) showed that the method of manual harvest has recorded a lower loss value at (877) \$. ha<sup>-1</sup> compared with the Semi-mechanized harvest (two rows) (889) \$. ha<sup>-1</sup> and Semi- mechanized harvest (single-row) (1210) \$.ha<sup>-1</sup> any difference (12) \$.ha<sup>-1</sup> between Semi- mechanized harvesting (two rows) and manual harvest at (321) \$.ha<sup>-1</sup> between semi- mechanized harvest single-row and two rows) and (333) \$.ha<sup>-1</sup> between Semi- mechanized harvesting (single-row) and manual harvest.

Table (3): The relationship between harvesting methods and production traits

Harvesting Methods	Traits			
	Total loss \$. ha <sup>-1</sup>	Harvest costs \$. ha <sup>-1</sup>	Production ha. h <sup>-1</sup>	Time of the harvest process h. ha <sup>-1</sup>
T.R.S.M.H.	889	4.5	2.24	0.44
S.R.S.M.H.	1210	9	1.12	0.89
M.H.	877	64	0.003	315

T.R.S.M.H.= Two rows semi-mechanized harvest.

S.R.S.M.H.= Single-row semi-mechanized harvest.

M.H.= Manual harvest.

The data indicate that semi- mechanized harvesting (two rows), which recorded a lower cost of the harvest process, amounted to 4.5 \$. ha<sup>-1</sup> comparing with the Semi-mechanized harvest (single-row) 9 \$. ha<sup>-1</sup>. However, manual harvest 64 \$. ha<sup>-1</sup>. The high value of manual harvest is caused by the number of workers who contribute to it per hectare.

The table(3) showed that high productivity  $\text{ha.h}^{-1}$  in a Semi- mechanized harvest (two rows) and by  $2.24 \text{ ha.h}^{-1}$  compared with the Semi- mechanized harvesting (single-row)  $1.12 \text{ ha.h}^{-1}$  and manual harvest  $0.003 \text{ ha.h}^{-1}$ . This is due to the number of lines which Semi- mechanized harvest (two rows) work with, where the width increases compared to Semi- mechanized harvest (single-row) at the same speed, except it is much better compared to the method of manual harvest. Also, the time of completion of the harvest process is superior to Semi- mechanized harvesting (two rows). Finally, the rest of the harvesting methods recorded the last time to complete work amounted to  $0.44 \text{ h. ha}^{-1}$  and  $0.89 \text{ h. ha}^{-1}$  for semi-mechanized harvest (single-row) and  $315 \text{ h. ha}^{-1}$  for manual harvest.

### **CONCLUSIONS**

Based on the obtained results, the two rows of semi- mechanized harvesting achieved a lower percentage of damaged tubers of  $0.2 \text{ ton. ha}^{-1}$  and a higher percentage of lifted tubers about  $24.6 \text{ ton. ha}^{-1}$ , with the production of the ideal sample of  $25.49 \text{ ton. ha}^{-1}$ , and the highest productivity is  $2.24 \text{ ha. h}^{-1}$ . Further, lower harvest costs  $4.5 \text{ $. ha}^{-1}$ , and the lowest completion time of the harvest process  $0.44 \text{ h. ha}^{-1}$ . Unlike the manual harvest, which recorded a higher percentage of undamaged tubers, it reached  $20.76 \text{ ton. ha}^{-1}$  and the lowest percentage of damaged tubers with slightly damaged ones was  $2.24 \text{ ton. ha}^{-1}$ , quantitative loss about  $0.49 \text{ ton. ha}^{-1}$  with qualitative loss is  $3.63 \text{ ton. ha}^{-1}$  and less total loss of  $877 \text{ $. ha}^{-1}$ .

The lifted tubers and production were increased with the increase the number of harvest rows, while the severe damaged tubers, total loss, harvest costs, time of the harvest process were decreased .It must be mentioned that the farmer needs 45 workers to complete manual harvest for hectares per hour.

### **RECOMMENDATIONS**

Based on the results, the lowest loss percentage was recorded by manual harvest,  $877 \text{ $. ha}^{-1}$  and  $12 \text{ $. ha}^{-1}$  compared with Semi- mechanized harvest (two rows). However, it is recommended to use Semi- mechanized harvest (two rows) during harvesting potatoes compared to other methods because this will return to the farmer with better profits, lower harvest costs, and the fastest time of completion for the harvest process to conclude depending on the preceding information, we recommend using mechanized harvest (two rows) even if it is necessary to buy it because it will return to the farmer in making time short, a better productivity rate, lower harvest costs with a better quality of the crop. It is also recommended to use harvesters instead of semi-mechanized harvesting to provide that because they are much better compared to semi- mechanized harvesters in terms of the number of harvest lines, the quality of the crop and the reduction of the worker's number to complete the harvest process.

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### **CONFLICT TO INTEREST**

The Authors declare that there is no conflict of interest.

التحقق من تأثير استخدام طرق حصاد مختلفة على مؤشرات فقدان محصول البطاطا

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### الخلاصة

أجريت تجربة ميدانية في محافظة نينوى / العراق تم فيها دراسة تأثير ثلاث طرق لعملية الحصاد لمحصول البطاطا (الحصاد شبه الآلي، والذي يشمل حصاد خط واحد وحصاد خطين والحصاد اليدوي) على صفات (الدرنات السليمة، الدرناات المكدوشة خدش كبير، الدرناات المكدوشة خدش طفيف، الفقد الكمي، الفقد النوعي، الدرناات المقلوعة، الإنتاجية، زمن انجاز عملية الحصاد وتكاليف الحصاد والخسارة الكلية التي تصاحب كل طريقة). تم الحصول على أفضل أداء بالنسبة للحصاد شبه الآلي (خطين) حيث سجلت اقل نسبة للدرنات المكدوشة خدش كبير (0.2) طن/ هكتار واعلى نسبة للدرنات المقلوعة (24.6) طن / هكتار وإنتاج العينة المثالية (25.49) طن / هكتار واعلى إنتاجية (2.24) هكتار/ساعة واكل تكاليف حصاد بلغت 4.5 دولار/ ساعة واكل زمن انجاز لعملية الحصاد (0.44) ساعة / هكتار. في حين سجلت طريقة الحصاد اليدوي اعلى نسبة للدرنات السليمة (20.76) طن / هكتار واكل نسبة للدرنات المكدوشة خدش طفيف 2.24 طن / هكتار واكل نسبة للفقد الكمي 0.49 طن / هكتار واكل خسارة كلية (877) دولار / هكتار. واخيراً تبين في الحصاد اليدوي يحتاج المزارع على الأقل الى 45 عامل لإنجاز عملية الحصاد للهكتار الواحد خلال ساعة. **الكلمات الدالة:** الحصاد اليدوي، حصاد البطاطا، الفقد الكمي، الخسارة الكلية.

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