



Effect of Forward Speed and Single-Type Conveyer Inclination on Potato Crop Digging Index

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Abstract

The experiments were carried at Almrkhyat Agricultural Scheme in Karrary locality Omdurman city, Khartoum State in a sandy clay soil, and for a potato crop planted during winter season 2017. The potato cultivar was Zasira. The study aimed to investigate the effect of tractor different forward speeds (3.1, 3.7 and 4.09 km/hr) and the conveyer inclination (18° and 24°) of Potato Digger with Single type Chain Conveyers on some of potato crop index such as lifting and total damage percentage and machine performance in sandy clay soil. The results showed that, there was a highly significant influences of forward speeds and conveyer inclination on tubers lifting, Effective field capacity and fuel consumption, while there was no significant impact on total damage and wheel slippage ($P < 0.05$). The study found that the maximum tubers lifting of 98.63% at Sp1 with conveyer inclination, while the lowest value of lifting percentage of 89% when use the Sp3 and conveyer inclination 2, more while, the lowest percentage of 0.03% was at Sp1 with each conveyer inclination. According to the results of this study, it's recommended that, the proper condition to operate the potato digger to obtained best value for potato lifting percentage (98.63%), total damage percentage (0.03%), fuel consumption (8.83lit/fed) and wheel slippage (7.67%) is the combination of Sp1(3.1Km/hr) and conveyer inclination 1(18°).

Keywords: potato digger machine, lifting potatoes and potato total damage percentage and effective field capacity.

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Introduction

Potato is the major tuber crop grown in the country. It is a rich source of carbohydrate, used all over the country. Potato is harvested when it attains the physiologic maturity. Potato harvesting is time consuming

operation due to its various activity taken place at the same time.

Potato harvesting is one of the most important operations has to be performed exactly to have a good potato production. It has a direct effect on the potato bruising.

Bruising has an essential effect on potato marketing. The mechanical brushing could be happened when the tractors wheels roll on the potato rows during harvesting.

There is different equipment of harvesting the potato from the field. This equipment is tractor operated, animal drawn, or hand operated. Tractor operated potato digger cum elevator is mainly used for digging and exposing potato tubers simultaneously. The digger was found to perform very well under varying soil condition. A potato digger reduces 75% labour and 50% operating time compared to conventional method. It also results in 4-5% reduction in harvesting losses. (Devesh and Ashok, 2017).

Potato tubers damage and losses due to mechanical harvesting techniques are significant problems for growers nationwide. They can be minimized by studying the factors and improving harvesting methods and post harvest operations such as handling grading, storing and marketing. Hyde et al. (1983) reported that 60 % of tubers damage occurs after the tubers leave the harvester, but this damage could be reduced if more soils were eliminated by the potato harvester so that potato conveying equipment would not be required to both move the tubers and eliminate soil. There are many factors that directly affect the damage of potato tubers, such as: digger share, digger forward speed and chain speed, impact duration, soil load level in the primary chain, potato varieties, harvesting type, chain and soil conditions. (Arfa, 2007).

Siepman (1983) mentioned that harvesting by hand with a fork is very labour and time consuming depending on the conditions (climate, soil, yield etc. up to 300 man h/ha) and therefore only suitable on a small plot. Abdou (1985) studied the effect of mechanical harvesting on mechanical potato damage under the condition of clay soil and found that the use of mechanical harvesting

in mechanical planting area had higher percent of undamaged potato by comprise with mechanical harvesting in manual planting area. Mady (1991) concluded the low tractor forward speed 2.1 km/h., is preferable for potato harvesting, the suitable digging depth was 22 cm.

In Sudan ,There are problems regarding potato cultivation and storage. The collection of these problems causes the cut of product yield and rise of wastage value. Moreover, in Sudan, harvesting is usually performed manually or semi-mechanized, and share responsibility for the high cost of production. In the semi-mechanized harvesting, diggers are used, coupled to a tractor, which degrade the furrows and expose the tubers. Later, the collection is done manually by men or young women who also carry out a preliminary selection field.

Thus, this study aimed to study the potato crop handling and Performance evaluation of Potato crop digger with single Chain Conveyor to find the best optimized values of speed-inclination combination with respect to observed parameters, such as EFC, fuel consumption, rear wheel slippage and potato lifting and damage %.

Materials and Methods

Experimental site:

The experiments were carried out in the Karray locality – Omdurman city, Khartoum State at Almrkhyat Agricultural Scheme owned by WAS Company in the area under the center pivot system. The experiment was conducted during May - 2017. Soil texture was found to be Sandy clay soil with moisture content of 7.59% during the experiments. The variety grown and harvested was Zasira, spaced 22 cm between plants and 90cm between rows , depth of 17 cm.

Experimental design and treatments applications:

In this study, a factorial experiment was (arranged in a split plot design with three replicates for each, the three forward speeds (3.1, 3.67 and 4.09 km/hr) were assigned to the main plots while the two conveyer inclination degree (18° and 24°) were distributed to the sub-plot respectively, giving a total of 18 plots. The treatments were randomly distributed in the main plot and sub plot, the sub plot area was 90m² (50m × 1.8m) and was separated by a distance of 2m between each sub plots and by distance of 10m at the end of sub plot.

Amounted digger Fig. 1 was used for all tests, the specifications of the potato crop digger was presented in Table 1.

Measurement

The following performance parameters were determined to evaluate the root drop digger

Crop parameters

Number of tubers per meter row length

The numbers of tubers were counted in one meter row length. The counting was done before harvesting of crop. The data was recorded at ten places selected randomly.



Fig. 1: Potato harvesting machine used in this research

Table 1: Technical specifications and characteristics of the tractor and potato digger

Characteristics	Description
Tractor	
Brand	Massy Ferguson
Model	MF440
Engine Power	61.1 kW (82 hp)
Potato digger	
Brand	Grimme
Model	---
Number of rows	2
Number of conveyor	1
Working Width	1.8 m
Share shape	Trapezium
Share width	-- cm
Hitching	Three point linkage

Depth of crop

The data was recorded at ten random places. The depth was measured by a measuring scale after removing the soil from side of the bed. The depth adjusted for this experiment was 22cm, Mady, (1991).

$$Lift\ potato\ \% = \frac{c}{d} \times 100 \dots\dots\dots(3.1)$$

Where,
c is the total number of digged potato.
d is the total number of potato (digged and un-dug both).

Total damage percentage

Total damage potato was calculated to know the percentage of potato which was damage

$$D\% = \frac{w_1}{w_1 + w_2} \times 100 \dots\dots\dots(3.2)$$

Where,
*W*₁ is the total weight of damage potato by the digging machine.
*W*₂ is the total weight of un-damage potato by the digging machine.

$$EFC = \frac{A}{T_p + T_1} \dots\dots\dots(3.3)$$

Where,
 EFC = Effective field capacity, ha h⁻¹
 A = Area covered, ha
 TP = Productive time, h
 T1 = Non-productive time, h
 (Time lost for turning, excluding refueling and machine trouble).

Fuel consumption

For measuring the fuel consumption of tractor, the fuel tank was filled up to neck of

$$S (\%) = \left(1 - \frac{V_a}{V_t} \right) \times 100 \dots\dots\dots(3.4)$$

The actual travel speed (*V*_a) for tillage was measured using stopwatch to record the time taken by the tractor to travel specific distance (100 m). Theoretical travel speed (*V*_t) of the tractor was measured by the same way mentioned above with the implements raised up and the tractor traveled the same distance (100 m).

Tubers lifting

The lift potato was calculated to know how much of the potato remained un-dug. It was defined as follows

by the digging machine by each part of machine. Random samples of tubers after lifted on the soil surface were collected from each treatment and classified as follows: damage potatoes due to harvesting operation and un-damage potatoes was defined as follows, (Mahmoud, 1992)

Effective field capacity (EFC)

The actual operating time along with time lost for turning of machine were recorded in the field test area. The effective field capacity of the machine was calculated as follows

the fuel tank before and after the digging operation. The amount of refilling measured after the test was the fuel consumption for digging operation and it was expressed as liter per hour.

Rear wheel slippage (%)

The tractor rear wheel slippage (*S*) was calculated as a percentage of loss of forward speed as in the following equation :

Statistical Analysis of the data

In order to see the significance of results for lifting percentage, Total damage percentage, field capacity, fuel consumption and wheel slippage the data were subjected to the statistical analysis by the analysis of variance technique programme given by Statistix8. Least significance difference (LSD) was also calculated at 5 percent level of significance.

Results and Discussion

Effect of conveyer inclination and forward speed on Tubers lifting percentage:

The statistical analysis of data on the effect of study variables on the potatoes tubers lifting percentage indicated that, the tubers lifting was highly influenced by interaction of angle and forward speed ($P < 0.05$) and there was a significant effect by different speeds at 5% level of significance (Table 2). While, the conveyer inclination was non-significant ($P > 0.05$) as shown in (Table 2).

The mean values of tubers lifting percentage at different forward speeds and conveyer

inclination is shown in Fig. 2. From Fig. 2, it can be seen that as the forward speed of the digger increased from Sp1 (3.1km/hr) to Sp2 (3.7km/hr), the lifting percentage increased from 89.53 to 98.63%, while it was decreased to 91.67% as the forward speed increased to Sp3 (4.09 km/hr) at conveyer inclination of 18° . Similarly the lifting percentage increased from 94.3 to 95.03% and decreased from 95.03 to 89% as the forward speed increased from Sp1 to Sp2 and from Sp2 to Sp3 at conveyer inclination of 24° , respectively.

Table 2: ANOVA description for all observed parameters at different forwards speed, harvesting depth and conveyer inclination and their interactions.

Observed parameters	Lifting		Damage		Wheel slippage		EFC		Fuel consumption	
	P	SS	P	SS	P	SS	P	SS	P	SS
Speed	0.02	53.6	0.27	1.89	0.44	1.44	0.06	0.019	0.00	3.4
inclination	0.01	36.12	0.12	0.66	0.66	0.88	0.25	0.006	0.60	0.02
Speed × inclination	0.00	177.5	4.75	0.08	0.09	30.1	0.00	0.124	0.00	8.03

EFC = Effective field capacity, P = probability SS = sum. of Square.

From Fig. 2, it can also be seen that as the conveyer inclination of the digger increased from 18° to 24° , the lifting percentage decreased from 94.3 to 89.53 % and from 98.63 to 95.03% and further decreased from 91.67 to 89% at speed Sp1, Sp2 and Sp3, respectively.

The treatment of Sp2 + conveyer inclination 1, may be considered as best optimized

value for potato lifting percentage(98.63%) of the potato crop.

The findings regarding tubers lifting percentage are in conformity with those of (Naji, 2005 and (Narender, 2012) who found that, as the forward speed of the digger increased the un-dug potatoes increased.

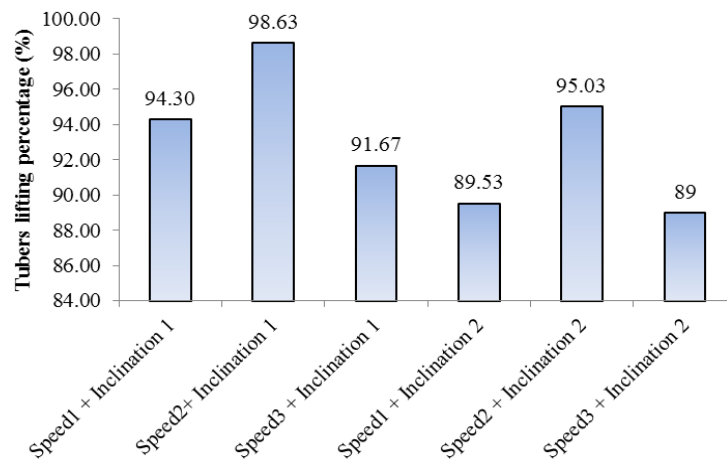


Fig.2: effect of conveyer inclination and forward speed on tubers lifting percentage (%)

Effect of conveyer inclination and forward speed on total damage percentage:

Variation in forward speeds and conveyer inclination showed a non- significant impact on Total tubers damage percentage at ($P < 0.05$) (Table 2). Further, the values of total damage percentage were not significant for interaction of speed and conveyer inclination as indicated in Table 2.

The mean values of total damage percentage at different forward speeds and conveyer inclination are shown in Fig. 3. From Fig. 3, it can be seen that as the forward speed of the digger increased from Sp1 (3.1km/hr) to Sp2 (3.7km/hr) and from Sp2 to Sp3 (4.09km/hr), the total damage percentage increased from 0.03 to 0.13% and from 0.13 to 1.23% at conveyer inclination of 18°. Similarly the total damage percentage increased from 0.03 to 0.17% as speed increased from Sp1 to Sp2 respectively, and from 0.17 to 1.53% when the forward speed of the digger increased

from Sp2 to Sp3, at conveyer inclination of 24°.

From Fig. 3, it could also be seen that as the conveyer inclination of digger increased from 18° to 24°, the total damage percentage increased from 0.13 to 0.17 at forward speed 2(3.7 km) and further increased from 1.23 to 1.53% as conveyer inclination increased 18° to 24° at Sp3 (4.09km/hr), respectively. These results are in line with findings of (Naji, 2005 and (Narender, 2012) who found that, as forward speed of the digger increased the total damage percentage increased. Also these results are agreed with findings of Arfa 2007 who found that, the increase in chain inclination led to increase in the damage of tubers.

The treatment of Sp1 + conveyer inclination 1 and conveyer inclination2, may be considered as best optimized value for potato total damage percentage (%) of the potato crop.

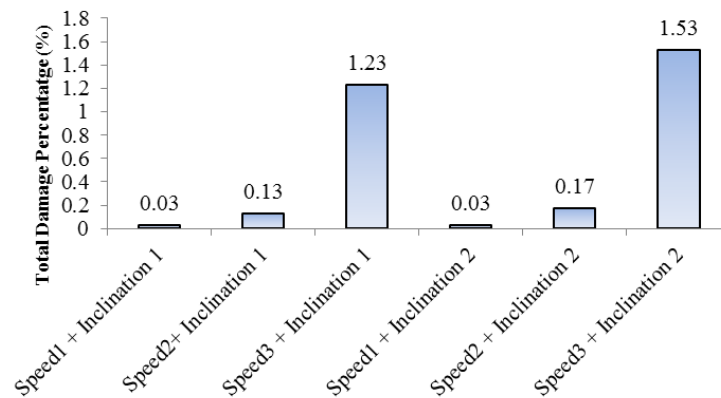


Fig.3: effect of conveyer inclination and forward speed on total damage percentage (%)

Effect of conveyer inclination and forward speed on Effective field capacity

Table (2) indicates that, there was a highly significant difference on effective field capacity when it was influenced by the interaction of forward speed and conveyer inclination ($P>0.05$), while the effect of forward speed and conveyer inclination on effective field capacity was not significant at ($P>0.05$) (Table 2).

There was a consistent increase in the effective field capacity with increase in forward speed from Sp1 to Sp2 and Sp3. Pooled data of effective field capacity showed that forward speed of Sp3 was having the highest effective field capacity of 1.66fed./hr which was nearly 16.3% and 18.07% more than that at (Sp2) and (Sp1), respectively at conveyer inclination of 18° (Fig.5). Similarly, with increase in forward speed, the effective field capacity goes on increasing. Highest effective field capacity of

1.54 fed./hr was recorded due forward speed at highest forward speed of 4.09km/hr as compared to other two speeds of 3.1 km/hr and 3.7km/hr at conveyer inclination of 24° (Fig. 4).

From Fig. 4, it could also be seen that as the conveyer inclination of digger increased from 18° to 24°, the effective field capacity increased by 4.22% and 8.55% at Sp1 and Sp2, respectively. Where it was decreased by 7.22% at forward speed 3 of 4.09 km/h.

This increase in the EFC with increase in the forward speed might be due to that fact, field capacity is mainly affected by speed travels in the field, time losses and width of machine and this agrees with (Kepner et al 1982 and Kheiry and Dongxing, 2016).

The treatment of Sp3 + conveyer inclination 1, may be considered as best optimized value for effective field capacity of the tested machine. Fig. 4.

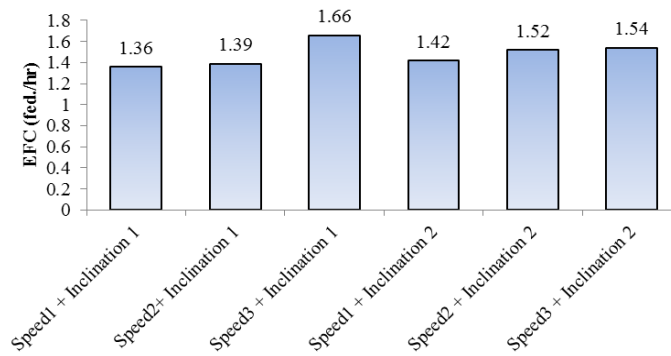


Fig.4: effect of conveyer inclination and forward speed on EFC (fed./hr)

Effect of conveyer inclination and forward speed on fuel consumption

The values of fuel consumption were highly significant for different forward speed and interaction of forward speed and conveyer inclinations as indicated in Table (2). However, the conveyer inclinations showed no significant effect on fuel consumption as shown in Table (2).

The details of the values of fuel consumption affected by forward speed and conveyer inclinations are given in Fig. 6. From Fig. 3 it can be seen that as the forward speed increased from Sp1 to Sp2 and from Sp2 to Sp3 the fuel consumption increased from 8.83 to 10 lit/fed and from 10 to 11.05 lit/fed, respectively at the conveyer inclinations of 18°. Furthermore, the results showed that the average fuel consumption in the highest speed was generally higher

compared to lower speeds. The average fuel consumption of 10.8 Lit/fed which recorded for the Sp3 was observed to be higher than (Sp 2) and (Sp 1) by 6.02% and 14.8%, respectively at the conveyer inclinations of 24°, (Fig. 5). This result agrees with Kheiry and Dahab (2017); Kheiry and dongxing (2016) who found that, there was a positive relation between forward speed and fuel consumption.

Similarly an increasing trend was observed for the fuel consumptions from 8.83 Lit/fed to 9.2 Lit/fed and from 10. to 10.15 lit/fed and as the conveyer inclination increased from 18° to 24° at Sp1 and Sp2, respectively (Fig.5).

The treatment of Sp1 + conveyer inclination 1, may be considered as best optimized value for fuel consumption (Fig. 5).

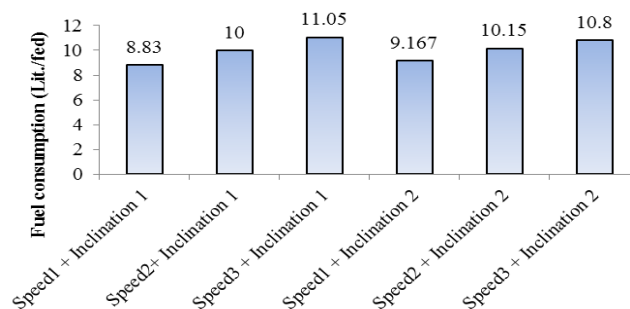


Fig.5: effect of conveyer inclination and forward speed on fuel consumption (lit/fed.)

Effect of conveyer inclination and forward speed on wheel slippage

Forward speed and conveyer inclination have no significant effect on wheel slippage Table (2). As the forward speed increased from Sp1 to Sp3 the wheel slippage values increased . The increase in Wheel slippage at speed (3) was 11.33% for conveyer inclinations of 18° and 24° (Fig.6) . Collected data of wheel slippage indicated that the highest slippage of 11.33% was recorded by Sp3 of 4.09 km/hr and the lowest one of 7.7 and 8.7 recorded by Sp1 for the two conveyer inclinations .

From Fig. 6, it could also be seen that as the conveyer inclination of digger increased from 18° to 24°, the wheel slippage increased by 11.4% at Sp1, and by 3.2% at Sp2. These results are in agreement with the findings of other researchers (Kheiry and Dongxing, 2016, Kheiry and Dahab, 2017 and Kheiry, et al., 2017).

The treatment of Sp1 + conveyer inclination 1, may be considered as best optimized value for wheel slippage of the tested machine. (Fig.6).

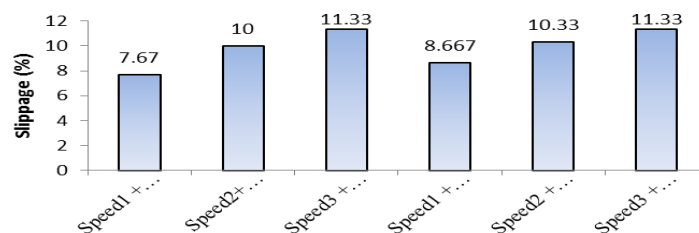


Fig. 6: effect of conveyer inclination and forward speed on wheel Slippage (%)

Conclusion

- 1) The percentage of lifting potatoes, total Damage percentage and machine performance such as travel reduction (wheel slippage), effective field capacity and fuel consumption were measured and evaluated under different forward speeds and different conveyer inclinations .
- 2) The treatment of Sp2 + conveyer inclination 1, considered as best optimized value for potato lifting percentage of the potato crop.
- 3) The treatment of Sp1 + conveyer inclination 1 and conveyer inclination2, considered as best optimized value for

potato total damage percentage (%) of the potato crop.

- 4) The treatment of Sp3 + conveyer inclination 1, may be considered as best optimized value for effective field capacity of the tested machine.
- 5) The treatment of Sp1 + conveyer inclination 1, considered as best optimized value for fuel consumption of the tested machine.
- 6) The treatment of Sp1 + conveyer inclination 1, considered as best optimized value for fuel consumption of the tested machine.

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تأثير السرعة الأمامية وزاوية ميل ناقل الدرنات لآلة قلع البطاطس أحادية الناقل على مؤشرات حصاد البطاطس

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المستخلص:

تم تنفيذ التجربة بأحد حقول البطاطس بمشروع المرخبات الزراعي في محلية كرري بمدينة أم درمان ولاية الخرطوم في تربة رملية طينية وعلي محصول تم زراعته في الموسم الشتوي للعام 2017م، والبطاطس التي تمت عليها الدراسة هي من الصنف زاسيرا (Zasira). هدفت الدراسة لدراسة تأثير سرعات الجرار بسرعات مختلفة وهي (3.1، 3.7 و 4.09 كلم/ساعة) و زاوية ميل ناقل الدرنات (الهزان) بقيم (18° و 24°) لآلة حصاد البطاطس أحادية الناقل الدرنات ودراسة تأثيرها علي بعض مؤشرات حصاد البطاطس مثل نسبة قلع البطاطس ونسبة التلف الكلية كما تمت دراسة أثرهم علي بعض عناصر أداء الآلة في الاراضي الرملية الطينية. أوضحت النتائج أن السرعة الأمامية للجرار و زاوية ميل ناقل الدرنات لهما تأثير عالي المعنوية علي نسبة النقل للبطاطس والسعة الحقلية الفعلية واستهلاك الوقود بينما لم يكن لهما أي أثر معنوي علي نسبة التلف الكلية وانزلاق العجل عند مستوي معنوية 5%. ووجدت الدراسة أن أعلى نسبة قلع كانت 98.63 وتحققت هذه النسبة عند استخدام السرعة الامامية وزاوية الميلان الاولييتين وأقل نسبة قلع 89% تحققت عند السرعة الامامية الثالثة وزاوية الميلان الثانية. بينما كانت أقل نسبة تلف كلية لدرنات البطاطس تساوي 0.03% عند استخدام السرعة الامامية الاولي مع كلا زاوية الميلانين. من خلال النتائج السابقة توصي الدراسة باستخدام السرعة الاولي (3.1 كلم/ساعة) مع زاوية الميلان الاولي (18°) وذلك بغرض الحصول علي اعلي نسبة قلع 98.63% واقل قيمة تلف 0.03% مع استهلاك وقود وانزلاق عجل في الحدود المعقولة والموصي بها بقيم 8.83 لتر/فدان و7.67% علي التوالي.