J. of Soil Sciences and Agricultural Engineering, Mansoura Univ., Vol. 11 (11):609-615, 2020

Journal of Soil Sciences and Agricultural Engineering

Journal homepage: www.jssae.mans.edu.eg
Available online at: www.jssae.journals.ekb.eg

Utilization of the Two-Wheel Tractor in Onion Digging Operation

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ABSTRACT

A front-mounted digger was especially manufactured to be used with the two-wheel tractor for digging onion bulbs, the digger mainly consists of a frame, two detachable shanks and digging blade. Two experiments were carried out in May 2018 at El Gemmieza Agricultural Research Station to evaluate the performance of the developed digger during digging two cultivars of onion namely Giza 20 and Giza red; by testing two types of digging blade namely smooth sharpened edge blade (SSB) and triangular fingered blade (TFB) at three different blade angles of 5°, 10° and 15°. The un-lifted bulbs, damaged bulbs, digging efficiency, onion bulbs storability, required power (kW), consumed energy (kW.h/fed) and total cost were taken into consideration. The results revealed that the TFB caused damaged bulbs ranged between 23.2 – 36.04% and 20.22 – 33.46% with Giza red and Giza 20 respectively; compared to 1.72 – 3.08 % and 1.13 – 2.75 % respectively in case of SSB, so that the TFB cannot be used with the developed digger. The results indicated also that; increasing the blade angle decreased the un-lifted and damaged bulbs; and increased the digging efficiency, onion bulbs storability, required power and consumed energy with the two onion cultivars. The highest digging efficiency for SSB and TFB was obtained at blade angle of 15° with the two onion cultivars. The highest total digging cost was 96.6 LE/fed and 107.6 LE/fed for SSB and TFB respectively. Therefore; the developed digger can be used with the two-wheel tractor with SSB at blade angle of 15°.

Keywords: - Two-wheel tractor, onion digger, type of blade, digging efficiency and onion cultivars.

INTRODUCTION

In Egypt, almost of agricultural land holdings are small. The number of holders with less than 1 fed increased from about 1050.9 thousand in 1990 to 2143.9 thousand in 2010, while the agricultural land held by them was increased from 508.1 thousand fed to 923.6 thousand fed. Also, the number of landholders with less than 5 fed increased from about 877 thousand in 1950 to around 4.1 million in 2010, representing around 92% of all landholders in Egypt, (FAO, 2017).

In season 2014/2015, the total cultivated area of fully grown onion in Egypt was 196968 fed, which gave total production of 3040607 Mg, (Central Agency for Public Mobilization and Statistics, 2017). Onions are one of Egypt's most important crops in terms of local consumption and exports, as they are the third most important export crop after oranges and potatoes. Egypt's productivity of onions is close to 3 million tons. Egypt is one of the ten most productive countries of onions in the world. The exports of Egyptian onions at end of 2019 recorded 550,000 tons, compared to 310,000 tons in 2018. (FAO, 2020)

Selection of proper size of farm power and machinery is the most important component of any farm enterprise. Among the various inputs to the crop production system, power and machinery jointly represent the largest single item of expenditure constituting about 60% of the total investment on a farm. The decision on optimum size of machinery is quite critical not only because of the high proportion of total cost attributed to machinery but also due to the infrequency and irrevocability of such decisions, (Dash and Sirohi, 2008). Abdul Mottaleb *et al.* (2016) stated that, there is strong advocacy for agricultural machinery appropriate for smallholder farmers in South Asia. Such 'scale-appropriate' machinery can increase returns to land and labor, although the still substantial capital investment required can preclude smallholder ownership.

The power tiller is a multipurpose hand tractor designed primarily for rotary tilling and other operations on small farms. While in operations, an operator walks behind to maneuver it. It is also known as a garden tractor, hand tractor, walking tractor or a two wheel tractor. Implements initially offered with the power tillers included rotavator attachment, trailer and in some cases a plough and ridger, (Kathirvel *et al.* 2000). In rural area, two–wheel tractor is widely used due to its cheaper cost and multi–functionalities. Considering the fact that the average farm size in Laos is about 1.62 ha, (MAF, 2000). Sumner and Williams (2007) stated that the two-wheel drive tractor is most commonly used in dry or upland farming situations and for transportation. It ranges in size from 5 hp to 200 hp and need 80% of the weight distributed over the rear axle to maximize traction. The biggest advantages of that tractor over other 4-wheel tractors are smaller turning circle, simplicity of design, fewer mechanical parts and lower purchase price. However, a 2WD tractor does not work at all well in wet, hilly and muddy conditions. Hossain *et al.* (2017) stated that the two-wheel tractor (power tiller) is a common tillage tool in Bangladesh agriculture for easy access in fragmented land with affordable price of small farmers.

Mizrach *et al.* (1983) carried out a design of machine for digging, picking up, and separating peanut. The technique of machine used depended upon cutting the soil

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DOI: 10.21608/jssae.2020.135648

with peanut, plant and elevates all on screen with space equal 10.5 mm between the rods to loosen the soil. Hamam (1991) stated that the pulling force required to uproot a single plant depends mainly on bulb base diameter and secondary on root hairs number, increasing each of them increases the require pulling force. And suggested that adding a digging device may help in improving the pulling efficiency for onion harvesting. Duane Kido *et al.* (2006) showed that the bulb onions are typically harvested by uprooting them with a breaker bar that is pulled in the soil beneath the onions thereby surfacing the bulbs. Morad *et al.* (2007) compared between different sugar beet harvesting methods at different soil moisture contents of 15, 18, 21, 24 and 27% on wet basis. The results showed that the soil moisture content of 24 % is considered the optimum value during harvesting sugar beet crop regarding to lifted, un-lifted, damaged and bruised beets. Yousef (1995) developed an onion digger and evaluated its performance at different types of share namely straight, triangle, double triangle and three point share, at different cutting angle of 10°, 17°, 24° and other variables like as forward speed, spinner wheel speed and vibrating sieve frequency. He recommended that the use of the three point share at cutting angle of 17° and forward speed of 2.64 km/h to have the lowest of total damage percentage of onion bulbs. Refaey (2010) found that increasing each of share depth and share tilt angle increased harvesting efficiency, fuel consumption, power requirement and slip ratio and decreased each of damage ratio and field efficiency. In addition, the results referred to the optimal conditions are share depth of 7cm, share tilt angle of 25° and soil moisture content of 20.5%. Singh (2014) stated that the average operational depth of 7.62 cm of the developed digger was suitable with practically no damage to the onion bulbs. The lift percentage, mean digger efficiency and damage percentage were 94.9, 89.8 and 5.1, respectively. It was found also that there was 58 percent and 49 percent saving of labor and cost, respectively. Omar *et al.* (2018) developed an onion digger and evaluated its performance at soil moisture content of 22% and rake angle of 15˚ and stated that, the blade was inclined by an angle of 15˚ to horizontal to lift the soil with onion bulbs and throw it above to the elevator device. The results indicated that the recommended digging depth was 10 cm. Kandil *et al.* (2010) indicated that Giza 20 and Composite 9 had the heaviest bulb weight, followed by Giza red. Highest percentages of TSS and dry matter were obtained from Giza White, followed by Giza 20. The main objective of this study is to manufacture a front-mounted onion digger can be used especially with the two-wheel tractor, and to evaluate its performance.

MATERIALS AND METHODS

The developed digger was manufactured and evaluated at El-Gemmieza Agricultural Research Station, El-Gharbia Governorate, in May of 2018. The main purpose of this study is to manufacture a front-mounted onion digger can be used especially with the two-wheel tractor, and evaluate its performance while digging two onion cultivars; Giza 20 and Giza red.

The two-wheel tractor:-

There are more of types of the two-wheel tractor which holding by the Egyptian farmers. Where the used two-wheel tractor is Chinese-made and has Diesel engine (ZH1100 model) of 11.03 kW of output power at 2200 rpm. The distance between the vertical center lines of the two wheels was adapted to be 120 cm the same distance between the ridges. The specifications of the used two-wheel tractor are shown in Table (1).

Table 1. Some specifications of the used two-wheel tractor

No.	Items	Specifications	No.	Items	Specifications
1	Engine type	ZH1100 Chinese-made	6	Total width, cm	140
2	Engine power, kW	11.03	7	Total height, cm	100
3	Cooling system	Evaporation	8	Total weight, kg	300
4	Steering	handlebar	9	Wheels diameter, cm	72
5	Total length, cm	230	10	Wheels width, cm	20

Salient features of the developed digger:-

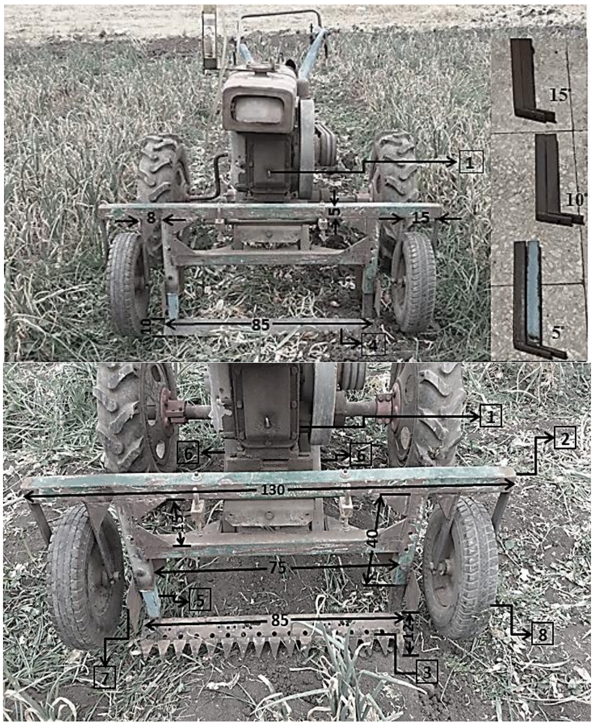
As shown in Figs. (1) and (2); the developed onion digger is a front-mounted equipment that consists of a frame, two detachable shanks and digging blade.

1- The frame:-

The frame was made from hallow square section of mild steel bar 5×5×0.4 cm of section dimensions, and it includes two horizontal beams, the upper one has total width of 130 cm and its main task is to join the frame with the two-wheel tractor by two bolts in place of the balance weights. While the lower beam has total width of 75 cm and its main task is to transfer the pushing force of the two-wheel tractor to the blade through joining it with middle of the two-wheel tractor chassis by other two hollow square section beams 4×4×0.4 cm of section dimensions and 80 cm in length. The frame includes also two vertical beams has the same section dimensions of 5×5×0.4 cm and 40 cm in length, the vertical beams joining the upper beam with the lower beam at vertical distance of 15 cm. the main task of the vertical beams is to join the two shanks with the frame. Also two plates were welded beneath and outside of the vertical beams for windrowing the bulbs after digging. Also two vertical forks were welded at the two ends of the upper beam for constructing two wheels to reserve the depth stability during digging operation, the distance between vertical center lines of the wheels has been adjusted to be 120 cm to fit the movement in surrounded ridges.

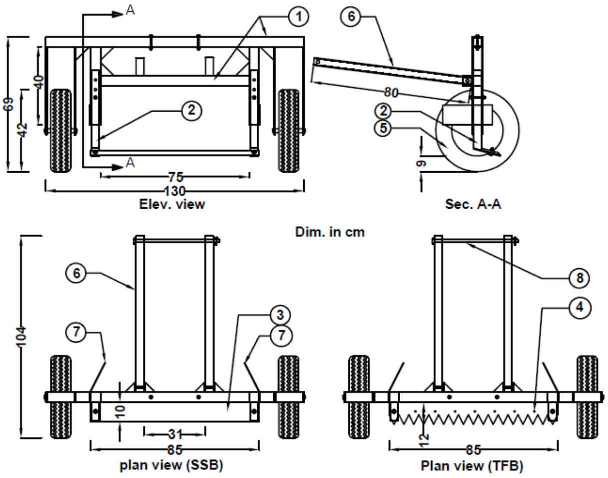
2- Detachable shanks:-

A pair of detachable shanks L-shaped were made, the vertical side had total length of 40 cm and made from hallow square section of mild steel bar 4×4×0.4 cm of section dimensions, where the horizontal side was made from flat mild steel 14×4×1 cm of dimensions which welded with the vertical side at a specific angle. The horizontal side of the shank has a 1.5 cm of diameter hole for bolting the blade during digging operation. Also, the vertical side of the shank has three holes for joining with the vertical beams of the frame by means of a bolt and for varying the digging depth through mating with a corresponding other two holes provided on the mentioned vertical beams. In order to vary the blade angle, three pairs of the mentioned shanks was made According to the required angle of (5˚, 10˚ and 15˚).



1	The two-wheel tractor	5	Shank
2	The main frame	6	Pushing rod
3	Triangular fingered blade	7	Windrowing plate
4	Smooth sharpened edge blade	8	Digger wheel

Fig. 1. A view of the developed onion digger with the two-wheel tractor



1-	The main frame	5-	Digger wheel
2-	Shank	6-	Pushing rod
3-	Smooth sharpened edge blade	7-	Windrowing plate
4-	Triangular fingered blade	8-	Benz

Fig. 2. Schematic diagram of the developed onion digger

3- Digging blade:-

A detachable blade was used for surfacing the top layer of the soil with the onion bulbs. Two types of the blade were made for comparison purpose; the first is triangular fingered blade (TFB) which made from high carbon steel and has dimensions of 85×12×1 cm of length, width and thickness respectively, while the second is smooth sharpened edge blade (SSB) which made from spring steel and has dimensions of 85×10×1 cm of length, width and thickness respectively. Each end of the blade has a 1.5 cm of diameter hole for bolting with the shanks.

The connection of the developed frame with the two-wheel tractor is very easy; the upper beam of the frame joined to the tractor by means of two bolts in place of the balance weights of the tractor, and the lower beam of the frame has two link points at the same distance from midpoint. These two link points connected with the middle of tractor chassis by other two hollow square bars 4×4×0.4 cm of dimensions and 80 cm of length to transfer tractor pushing force to the digger frame. During digging operation, the two shanks are constructed telescopically in the two vertical beams of the frame and fixed by two bolts, and then the blade is joined on the two shanks.

Experiment field description:-

The harvested onion cultivars of Giza 20 and Giza red were transplanted manually on raised-beds, which has net width of 80 cm and the distance between centers of the sequenced ridges is 120 cm. The planting density was about 39 bulbs/m^2 (161000 bulbs/fed.). All agricultural process like as plowing, leveling, ridging, transplanting, irrigation, cultivation, weeding, fertilization and etc. were implemented by colleagues in Onion Research Section, Field Crop Research Inst. Agric. Res. Cent.. The physical properties of the harvested onion cultivars were clarified in Table (2), and the mechanical analysis of the experiment soil was clarified in Table (3).

Table 2. Some physical properties of the onion cultivars

No.	Items	Specifications	
		Giza 20	Giza red
1	Plant length, cm	83.85	87.04
2	Number of leaves/plant	9.9	10.07
3	Average bulb weight, gm	120.35	114.73
4	Rotandaty index	0.76	0.83
5	Polar diameter, cm	5.86	6.32
6	Equatorial diameter, cm	5.22	5.81

Table 3. Mechanical analysis of the experiment soil

Soil composition			Soil bulk	Soil
Clay, (%)	Silt, (%)	Sand, (%)	density, gm/cm^3	texture
44.37	41.97	13.66	1.15	Silty Clay

Experimental procedures:-

The digging operation of onion bulbs was carried out in May of 2018 at soil moisture content of 19.81% (d.b.). Meanwhile, the depth of the bulbs in the soil was measured for the two onion cultivars, and it was found that the shallow depth was found 4 cm, while the highest depth was found 6 cm, so all treatments were performed at a constant depth of 8.5 cm. Also, at a constant forward speed of about 1.5 km/h; the performance of the two-wheel tractor with the front-mounted developed digger was evaluated by studying the following factors:-

1- Two types of blade namely; triangular fingered blade (TFB) and smooth sharpened edge blade (SSB) were tested.
2- Blade angle was tested at 5°, 10° and 15° with soil surface.
3- Two onion cultivars, Giza 20 and Giza red.

Depending on the onion cultivars, two factorial experiments were conducted. The experiment was divided as mentioned in Fig. (3), as the main plots were specialized to the type of blade and the sub-main plots were specialized to the blade angle. Each treatment was replicated three times, the length of each treatment was 30 m and the width was 2.4 m.

Measurements:-

1- Un-lifted bulbs percentage, (ul):-

The onion bulbs remained in the soil after each treatment called un-lifted bulbs which collected, weighted and taken as a percentage by the following equation:-

$$\boldsymbol{ul}, \% = \frac{\boldsymbol{ul_w}}{\boldsymbol{ul_w} + \boldsymbol{L_w}} \times \mathbf{100}$$

Where; ul_w is weight of the un-lifted bulbs (kg) and L_w is weight of lifted bulbs (kg).

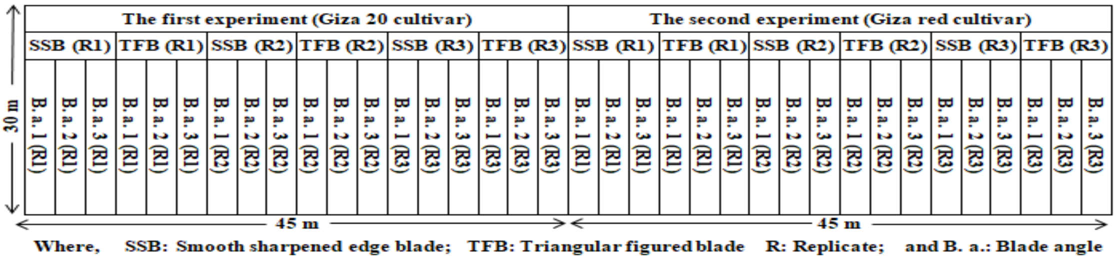


Fig. 3. Layout of the experimental field

2- Damaged bulbs percentage, (db):-

The damaged bulbs were separated, weighted and taken as a percentage by the following formula:-

$$d_b, \% = \frac{d_w}{L_w + d_w} \times 100$$

Where; d_w is weight of the damaged bulbs (kg) and L_w is weight of lifted bulbs (kg).

3- Digging efficiency, (ηd):-

The digging efficiency of the developed digger with the two-wheel tractor was determined by the following formula:-

$$\eta_d, \% = \frac{L_w - d_w}{ul_w + L_w} \times 100$$

4- Power requirement; (P) and consumed energy:-

A calibrated cup was modified to take direct reads for fuel consumption after each treatment, and the required power was calculated depending on the amount of consumed fuel by the following equation of Imbabie (1985):-

$$P = \frac{Fc \times \rho_f \times L.C.V \times 427 \times \eta_m \times \eta_{th}}{3600 \times 75 \times 1.36}, \qquad kW$$

Where:-

P = the required power, kW;
FC = consumed fuel, l/h;
ρ_f = fuel density 0.85 kg/l for diesel;
L.C.V = lower calorific value of fuel, 10000 kcal/kg;
427 = thermo mechanical equivalent, kg.m/kcal;
η_m = mechanical efficiency of engine, 80%;
η_{th} = thermal efficiency of engine, 35% for diesel engine.

Whereas the specific energy consumption (kW.h/fed) was calculated by dividing the required power (kW) on the effective field capacity (fed/h).

5- Storability

To study the storability of onion bulbs; 10 kg bulbs were taken from each treatment, then divided into 3 equal splits, each representing one replicate and stored on rack at room temperature for 6 months. Monthly observations were done to separate the rotten bulbs and estimate the weight loss. The percentage of the weight loss was estimated by the following formula:-

$$W_l = \frac{W_b - W_a}{W_b} \times 100, \quad \%$$

Where: - W_l is weight loss percentage, W_b is the sample weight before storing and W_a is the sample weight after storing (six months)

6- Cost analysis

The hourly cost for the two-wheel tractor with the developed digger was determined using the following equation, Hunt, (1983)

$$C = \frac{P}{H}\left[\frac{1}{y} + \frac{i}{2} + T + R\right] + [0.9\, W.S.F] + \frac{M}{144}, \qquad L.\frac{E}{h}$$

Where: –

C = hourly cost, L.E/h;	**H = yearly working hours, h/year;**
i = interest rate;	**R = repairs and maintenance ratio;**
W = engine power, hp;	**F = fuel price, L.E/l;**

P = price of two-wheel tractor, L.E;
y =life expectancy of the tractor, year;
T = taxes and overheads ratio;
0.9 = factor accounting for lubrications;
S = specific fuel consumption, l/h.hp;
M = monthly average wage, L.E;
144= is a reasonable estimate of monthly working hours.

RESULTS AND DISCUSSION

Un-lifted bulbs percentage:-

Fig. (4) shows the un-lifted bulbs percentage that occurred with the studied variables. As shown in the mentioned Fig., the un-lifted bulbs percentage with SSB was higher than that of TFB for the two onion cultivars at all blade angles; this is because TFB is more effective in soil handling due to its triangular finger and larger width compared to SSB (12 cm vs. 10 cm). As the values of the un-lifted bulbs which obtained with SSB were 1.55, 1.22 and 1.09% vs. 1.44, 1.14 and 0.71% with TFB for Giza 20 cultivar at blade angles of 5°, 10° and 15° respectively. In addition, with Giza red cultivar; the values of un-lifted bulbs which obtained with SSB were 1.63, 1.39 and 1.15% vs. 1.56, 1.20 and 0.73% with TFB under the same conditions.

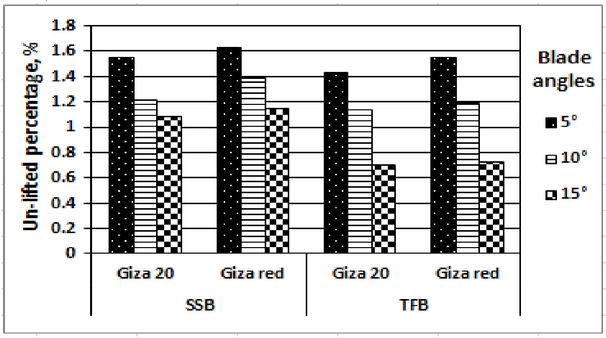


Fig. 4. Effect of blade type and blade angle on the un-lifted bulbs percentage for the two onion cultivars

The results cleared also that increasing the blade angle from 5° to 15° decreased the un-lifted bulbs percentage, the reason for that; increasing the blade angle with constant depth of the shank increases the digging depth. Increasing the blade angle from 5° to 15° led to decrease the un-lifted bulbs percentage from 1.55 and 1.63% to 1.09 and 1.15% with SSB for Giza 20 and Giza red respectively, also; decreased from 1.44% and 1.56% to 0.71% and 0.73% with TFB for Giza 20 and Giza red respectively.

A slight difference was observed between the values of un-lifted bulbs percentage for Giza 20 and Giza red cultivars; as a result to the difference in some physical properties of the two onion cultivars. The values of un-lifted bulbs with Giza red were higher than those of Giza 20 with the two blades at all blade angles.

The lowest values of the un-lifted bulbs percentage for SSB were 1.09 and 1.15% with Giza 20 and Giza red respectively; which obtained at blade angle of 15°; while, the lowest values of the un-lifted bulbs percentage for TFB were 0.71 and 0.73% with Giza 20 and Giza red respectively; and obtained under the same blade angle.

Damaged bulbs percentage:-

The effect of blade type and blade angle for the two onion cultivars were shown in Fig. (5), the obtained data showed that; the damaged bulbs percentage was very high with the triangular fingered blade (TFB) with the two onion cultivars comparing with the smooth sharpened edge blade (SSB), this is definitely due to the presence of triangular fingers that increase the chance of the plant coming into contact with the blade. The values of damaged bulbs with SSB were 2.75, 1.35 and 1.13% vs. 33.46, 25.83 and 20.22% with TFB; and obtained with Giza 20 cultivar at blade angles of 5°, 10° and 15° respectively. While, the damaged bulbs percentages with Giza red were 3.08, 1.83 and 1.72% with SSB vs. 36.04, 27.46 and 23.2% with TFB; which obtained under the same blade angles respectively.

The obtained data clarified also that, increasing the blade angle from 5°, to 15° decreased the percentage of damaged bulbs as a result to keep the blade edge away from the bulbs zone. Increasing the blade angle from 5° to 15° led to decrease the percentage of damaged bulbs of Giza 20 cultivar from 2.75% and 33.46% to 1.13% and 20.22% with SSB and TFB respectively, while with Giza red; it decreased from 3.08% and 36.04% to 1.72 and 23.20% with SSB and TFB respectively.

The obtained data cleared also that the values of damaged bulbs percentage for Giza 20 were less than those of Giza red. This may be because Giza red cultivar is juicier than Giza 20. As the values of damaged bulbs were 2.75, 1.35 and 1.13% with Giza 20; compared to 3.08, 1.83 and 1.72% for Giza red, these results obtained with SSB at 5°, 10° and 15° of blade angles respectively.

The lowest values of damaged bulbs for SSB were 1.13% and 1.72% with Giza 20 and Giza red cultivars respectively; and obtained at blade angle of 15°, while; the lowest values of damaged bulbs with TFB were 20.22 and 23.20% with Giza 20 and Giza red respectively, and obtained at the same blade angle.

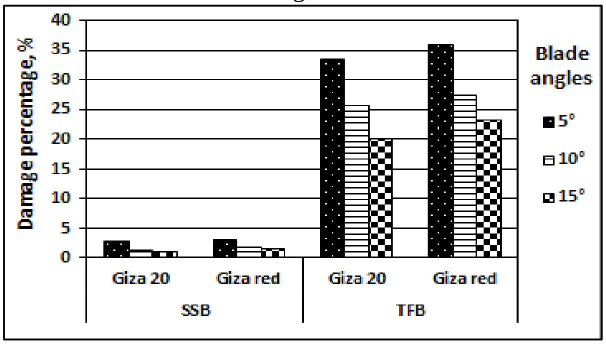


Fig. 5. Effect of blade type and blade angle on the damaged bulbs percentage for the two onion cultivars

Digging efficiency:-

As shown in Fig. (6) the digging efficiency for SSB was higher than that of TFB with the two onion cultivars due to high values of damage that occurred with TFB. As the digging efficiency values of 95.70, 97.43 and 97.78% were obtained with SSB for Giza 20 at blade angles of 5°, 10° and 15° respectively; compared to 65.10, 73.03 and 79.07% with TFB. Also with Giza red under the same conditions respectively; the digging efficiency values were 95.29, 96.78 and 97.13% with SSB compared to 62.40, 71.34 and 76.07% with TFB.

The digging efficiency increased by increasing the blade angle; as a result to decrease the un-lifted and damaged bulbs percentages. The digging efficiency increased from 95.29% & 62.40% to 97.13% & 76.07% by increasing the blade angle from 5° to 15° for SSB & TFB respectively with Giza red cultivar, and increased from 95.70% & 65.10% to 97.78% & 79.07% with Giza 20 for SSB & TFB respectively by increasing the blade angle from 5° to 15°.

With SSB; slight difference was remarked in the values of digging efficiency between the two onion cultivars. But with TFB; the digging efficiency of Giza 20 was higher than that of Giza red; as a result to the high values of damaged bulbs which occurred by TFB especially with Giza red cultivar.

The highest values of digging efficiency for the smooth sharpened edge blade (SSB) were 97.78 and 97.13% with Giza 20 and Giza red respectively; which obtained at blade angle of 15°, while with TFB; The highest values of digging efficiency were 79.07 and 76.07% with Giza 20 and Giza red respectively; and obtained under the same blade angle of 15° .

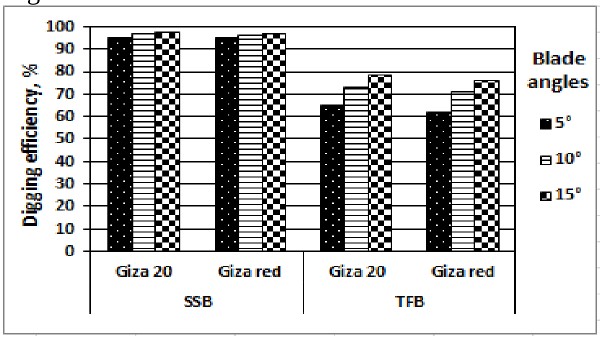


Fig. 6. Effect of blade type and blade angle on digging efficiency during digging the two onion cultivars

Power requirement and consumed energy:-

The data presented in Fig. (7) represent the required power (kW) for the two blades with the two onion cultivars at all blade angles, and the data presented in Fig. (8) represent the specific energy consumption (kW.h/fed). As shown in Fig. (7); a difference in the required power values was observed between the two blades during digging the two onion cultivars in favor of SSB, as the values of power requirement of 5.56, 6.01 and 6.53 kW were obtained with SSB for Giza 20 cultivar at blade angles of 5°, 10° and 15° respectively; compared to the values of 6.25, 6.70 and 7.14 kW which obtained with TFB under the same conditions. This may be due to; the width of TFB of 12 cm is more than the width of SSB of 10 cm. Also, the energy consumption with TFB was higher than that of SSB as shown in Fig. (8); this is due to the required power with TFB is higher than that of SSB and the effective field capacity with SSB of 0.41 fed/h was higher than that of TFB of 0.38 fed/h. The energy consumption values of 13.57, 14.65 and 15.93 kw.h/fed were obtained with SSB for Giza 20 cultivar at blade angles of 5°, 10° and 15° respectively compared to the values of 16.46, 17.63 and 18.79 kW.h/fed which obtained with TFB under the same conditions.

Also; the required power and energy consumption increased by increasing the blade angle during digging the two onion cultivars; as a result to increase the fuel consumption rate. The required power increased from 5.56 & 6.25 kW to 6.53 & 7.14 kW for SSB & TFB respectively by increasing the blade angle from 5° to 15° during digging Giza 20 cultivar. Also; the energy consumption increased from 13.57 & 16.46 kW.h/fed to 15.93 & 18.79 kW.h/fed for SSB & TFB respectively by increasing the blade angle from 5° to 15° with Giza 20 cultivar.

The results also indicated that the onion cultivar didn't affect the required power and energy consumption values.

With Giza 20 cultivar; the highest values of the required power for SSB and TFB were 6.53 & 7.14 kW respectively; which obtained at blade angle of 15°; and the lowest values were 5.56 and 6.25 kW respectively and were obtained at blade angle of 5°. With Giza red, the highest values of the required power for SSB and TFB were 6.48 & 7.11 kW respectively; which obtained at blade angle of 15°; and the lowest values were 5.84 and 6.31 kW respectively and were obtained at blade angle of 5°.

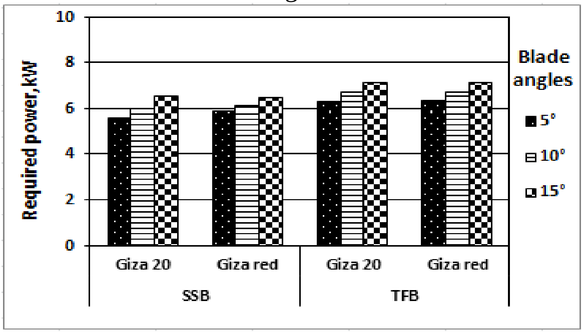


Fig.7. Effect of blade type and blade angle on the required power for the two onion cultivars

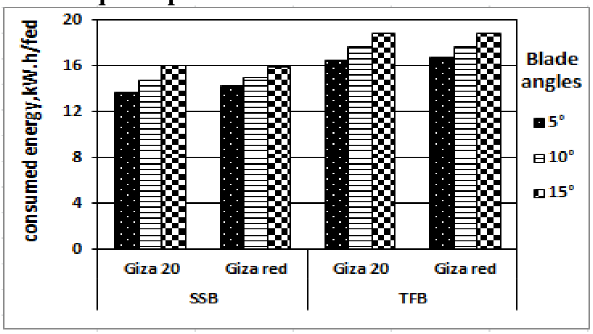


Fig. 8. Effect of blade type and blade angle on energy consumption for the two onion cultivars

With regard to energy consumption; the highest values of the consumed energy with Giza 20 cultivar for SSB and TFB were 15.93 & 18.79 kW.h/fed respectively; which obtained at blade angle of 15°; and the lowest values were 13.57 and 16.46 kW.h/fed respectively and were obtained at blade angle of 5°. With Giza red, the highest values of the consumed energy for SSB and TFB were 15.80 & 18.72 kW.h/fed respectively; which obtained at blade angle of 15°; and the lowest values were 14.24 and 16.61 kW.h/fed respectively and were obtained at blade angle of 5°.

Storability:-

The weight loss percentage indicates the onion bulbs storability, as less weight loss percentage in the store means high storability of onion bulbs and vice versa. Table (4) shows the weight loss percentage during storage period for the two onion cultivars under the influence of the two types of blade and blade angles, the obtained data showed that the weight loss during storage period was very high with the triangular fingered blade (TFB) compared to the smooth sharpened edge blade (SSB), this is because the bulbs may have subjected to invisible damage or more stress with TFB comparing with SSB.

Also, the results indicated that the weight loss percentage decreased by increasing the blade angle as a result to keep the edge of blade away from the bulbs zone. The obtained data showed also that the weight loss percentage during storage period was very high with Giza red comparing with Giza 20. This may be because Giza red cultivar is juicier than Giza 20.

The lowest weight loss percentages for SSB and TFB were 11.9 and 12.4% respectively with Giza 20 cultivar; which obtained at blade angle of 15°, in addition; the lowest weight loss percentages in case of Giza red cultivar were 13.2 and 13.5% with SSB and TFB respectively and obtained at the same blade angle.

Table 4. Weight loss Percentage during storage for the two onion cultivars under the influence of blade type and blade angle

	Smooth sharpened blade (SSB)			Triangular fingered blade (TFB)		
	Blade angles			Blade angles		
	5°	10°	15°	5°	10°	15°
Giza 20	12.3	12.1	11.9	12.9	12.6	12.4
Giza red	13.9	13.6	13.2	14.1	13.8	13.5

Cost analysis:-

As mentioned in Table (5), the lowest values of total cost of onion bulbs digging operation by the developed digger with the two-wheel tractor were 91.6 and 93.0 LE/fed; which obtained with SSB for Giza 20 and Giza red respectively; at blade angle of 5°. Whereas; the values of total cost of 102.7 and 103.0 LE/fed were the TFB lowest values; which obtained with Giza 20 and Giza red respectively at blade angle of 5°. Also; the highest values of total cost for SSB with Giza 20 and Giza red respectively were 96.6 and 96.3 LE/fed; and obtained at blade angle of 15°, whereas; the highest values for TFB were 107.6 and 107.5 LE/fed with Giza 20 and Giza red respectively; which obtained at blade angle of 15°.

The obtained results indicated that, the total cost for the triangular fingered blade (TFB) was higher than that of the smooth sharpened edge blade (SSB) with the two onion cultivars as a result to the effective field capacity with SSB was higher than that of TFB; 0.41 fed/h against 0.38 fed/h. Also; the total cost of digging operation was increased by increasing the blade angle as a result to increase the fuel consumption rate.

Also, the results indicated that; no difference in the values of total cost was observed between the two onion cultivars.

Table 5. Total cost (LE/fed) of onion digging operation

	Smooth sharpened edge blade (SSB)			Triangular fingered blade (TFB)		
	Blade angles			Blade angles		
	5°	10°	15°	5°	10°	15°
Giza 20	91.6	93.9	96.6	102.7	105.2	107.6
Giza red	93.0	94.5	96.3	103.0	105.0	107.5

CONCLUSION

The results revealed that the highest values of damaged bulbs which occurred by the triangular fingered blade (TFB) were 33.46 and 36.04% with Giza 20 and Giza red respectively; and decreased to 20.22 and 23.2% respectively by increasing the blade angle from 5° to 15°, so the TFB cannot be used to dig the onion bulbs with the developed unit. The optimum blade angle was 15°; as the lowest un-lifted bulbs, lowest damaged bulbs, highest digging efficiency and highest storability of onion bulbs were achieved with the two onion cultivars. Also, increasing the blade angle decreased the un-lifted and damaged bulbs, and increased the digging efficiency, onion bulbs storability, required power, and consumed energy with the two onion cultivars. The highest digging efficiency for SSB and TFB with Giza 20 cultivar was 97.78% and 79.07% respectively; while, it was 97.13% and 76.07% respectively in case of Giza red. The storability of onion bulbs was affected by the type of blade and blade angle and varied according to the onion cultivar. The total cost of onion digging operation by the two-wheel tractor with the developed unit ranged between 91.6 – 96.6 LE/fed with SSB; and ranged between 102.7 – 107.6 LE/fed in case of TFB. The developed digger can be used with the two-wheel tractor with SSB at blade angle of 15˚ for the two onion cultivars.

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الإستفادة من الجرار ثنائي العجل في عملية تقليع البصل

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انتشرالجرار ثنائي العجل بشكل كبير لدى المزارعين المصريين، ويعتبر مصدر مهم للقدرة لديهم خاصة وأنه يتميز بإنخفاض سعره وكذلك انخفاض معدل استهلاكه للوقود، لذلك كان الهدف من البحث تحقيق الإستفادة العظمى منه وتطوير وحدة لتقليع البصل يمكن تعليقها عليه أمامياً. الوحدة المطورة تتكون بشكل أساسي من إطار مصنوع من أنابيب الحديد ذات المقطع المربع 5×5×0,4 سم، وزوج من القصبات التي يمكن فكها وتركيبها تلسكوبياً في الإطار حيث أنها مصنوعة من أنابيب الحديد المربع 4×4×0,4 سم، وكذلك سكينة قطع التربة والتقليع وهي مصنوعة من الحديد عالي الكربون، كما تم تركيب زوج من الإطارات الكاوتش لتثبيت العمق أثناء التشغيل. تم اختبار أداء الوحده المطورة مع الجرار ثنائي العجل بمحطة البحوث الزراعية بالجميزة في شهر مايو لعام 2018 بدراسة نوعين من سكينة القطع وهم السكينة ذات الحافة الحادة الملساء 85×10×1 سم والأخرى السكينة ذات الأصابع المثلثة 85×12×1 سم، وكذلك تم اختبارثلاث مستويات لزاوية السكينة وهي 5˚ و 10˚ و15˚، وذلك في تجربتين منفصلتين على صنفين من البصل وهم جيزة20 وجيزة أحمر. وقد أظهرت النتائج أن السكينة ذات الأصابع المثلثة لا تصلح للإستخدام مع هذه الوحدة المطورة حيث أنها أحدثت أعلى نسب تلف للبصيلات وهي 33,46 – 36,04% مع صنفي البصل جيزة20 وجيزة أحمر على الترتيب عند زاوية السكينة 5˚؛ وبزيادة زاوية السكينة إلى15˚ قلت نسب البصيلات التالفة إلى 20,22 – 23,2% على الترتيب، في حين أن أعلى نسب تلف مع السكينة الحادة الملساء كانت 2,75 – 3,08% مع الصنفين جيزة20 وجيزة أحمر على الترتيب وتم الحصول عليهما عند زاوية السكينة 5˚؛ وبزيادة زاوية السكينة إلى 15˚ قلت نسب البصيلات التالفة إلى 1,13 – 1,72%. كما أظهرت النتائج أن زيادة زاوية السكينة من 5˚ إلى 15˚ أدى إلى زيادة كل من كفاءة التقليع والقدرة التخزينية والقدرة المطلوبة لعملية التقليع والطاقة المستهلكة وتناقص كل من نسبة البصيلات الغير مقتلعة ونسبة البصيلات التالفة وذلك مع صنفي البصل. تم تحقيق أعلى كفاءة تقليع للسكينة الحادة الملساء والسكينة ذات الأصابع المثلثة مع صنفي البصل عند زاوية السكينة 15˚. أظهرت النتائج أيضاً أن القدرة التخزينية لكلا الصنفين تأثرت بنوع السكينة وكذلك زاوية السكينة كما اختلف التأثير باختلاف الصنف. التكاليف الكلية لتقليع فدان واحد من البصل باستخدام الوحدة المطورة مع الجرار ثنائي العجل تراوحت بين 91,6 – 96,6 جنيه في حالة استخدام السكينة الحادة الملساء، وتراوحت بين 102,7 – 107,6 جنيه في حالة استخدام السكينة ذات الأصابع المثلثة. وخلصت النتائج إلى أنه يمكن استخدام الوحدة المطورة مع الجرار ثنائي العجل بالسكينة الحادة الملساء وزاوية السكينة 15˚ لتقليع صنفي البصل جيزة 20 وجيزة أحمر.