Agricultural mechanization and engineering
Between existing and prospected: 271-285 FARM MACHINERY AND

SELECTING OPTIMUM SEEDBED PREPARATION SYSTEM AND HARVESTING METHOD FOR BARELY PRODUCTION IN NUBARIA SITE

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ABSTRACT

Four different seedbed preparation systems were used that are chisel plow (two passes), followed by disk harrow one pass (system 1), chisel plow one pass followed by disk harrow one pass (system 2), chisel plow one pass followed by rotary tiller (system 3) and rotary tiller (system 4). Seed drill has been used for sowing the crop. The highest yield was 1.055 Mg/feddan obtained at plowing depth of 10 cm by using chisel plow (two passes), followed by disk harrow one pass (system 1) and the lowest yield was 0.875 Mg/feddan obtained by using rotary tiller (system 4). The highest energy value was 76.86 MJ/feddan when using the rotary tiller and the other energy values were 38.23, 38.71 and 43.25 MJ/feddan when using chisel plow 2nd pass, disc harrow and chisel plow 1st pass respectively.

Two mechanical harvesting methods mower then thresher and combine harvester were compared. The mechanical harvesting methods were done at three different forward speeds 2.1, 3.2 and 4.0 km/h for mower and combine. Data showed that increasing forward speed from 2.1 to 4.0 km/h the grain losses increased from 1.97 to 3.26 % for mower and from 2.37 to 3.64 % for the combine header. Also, total combine grain losses increased from 5.05 to 7.51 %. The threshing grain losses were 3.47, 3.32 and 3.7 % at thresher feed rates 0.75, 1.0 and 1.25 Mg/h respectively with drum speed 25 m/s. The energy required was 295.22 MJ/feddan when using mower, binding & transfer and thresher; on the other hand, it was 87.21MJ/feddandan when using the combine harvester. The lowest total cost of seedbed preparation and planting was 66 LE/feddan in case of using system 4 while, the highest operating costs for seedbed preparation and planting with seed drill was 92.76 LE/feddan in case of

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using system 1 (chisel plow two passes + disk harrow) and seeding with seed drill. Also, the lowest criterion cost of harvesting method were 185.28 and 325.42 LE./feddan in case of using combine operating speed 2.1 km/h and (mower at 2.1 km/h + binding and transfer +thresher) respectively.

INTRODUCTION

Mechanizing the operations related to barley production is needed for increasing its yield. The productivity of traditional cultivation can be increased by incorporating improved components of tillage, sowing and harvesting methods. El-Sayed and Ismail (1994) indicated that yield is highly affected by the tillage technique. The highest yield was obtained with the improved tillage techniques (chiseling twice to a working depth of 15 cm, followed by disk harrowing and leveling) which increased by 11.25 and 22.53 % over traditional (chiseling twice to a working depth of 15 cm, followed by leveling) and minimum tillage technique (disk harrowing twice to a working depth of 12 cm followed by leveling) respectively. El-Hanafy et al. (1995) mentioned that, the use of chisel plow followed by rotary tiller can be recommended because it gave the best seedbed preparation in terms of lowest value of mean soil clod diameter and the highest yield of barley. Abdou (1996) illustrated that the use of chisel plow two passes at 18 cm depth gave grain and straw yields higher than that of the same operations at 10 cm. The use of disc harrow or rotary tiller after chisel plow gave higher yield of grain and straw compared with chisel plow two passes for wheat crop. Using a rotary tiller plow for 10 cm depth gave a higher barely yields (grain - straw) 4.74 and 8.86 %. Helmy et al. (2001) found that the rotary plow gave the lowest fuel consumption and energy requirements compared with the chisel plow (one pass), chisel plow (two passes) and moldboard plow followed by disk harrow. Where the energy requirements were (12.28, 13.35, 23.80 and 37.87 kWh/feddan) for rotary plow, chisel plow (one pass), chisel plow (two passes) and moldboard plow followed by disk harrow respectively.
Egyptian farmers have an increasing interest to use of the seed drill machine in a large scale for sowing cereal crops. The drilling sowing gave the best uniformity for plant distribution, more accurate depth and less amount of seeds.

Balach and Bukhori (1983) stated that the cutter bar (shatter) loss was 2.53%, cylinder loss was 0.18%, rack loss was 0.33% and shoe loss was 0.39%. The cutter bar losses were greater than other losses due to low lying (lodged) wheat passed over by the cutter bar to grain shattered on to the ground by reel and guard action. Mohsenin (1986) reported that mechanical damage to seeds and grains, which occur in harvesting, threshing and handling can seriously affect the viability and germination ability, growth vigor, insects and fungi attack, and quality of the final product. Hassan et al. (1994) found that, the total grain losses and criterion cost for combine were minimum and performance efficiency was maximum under the following conditions:

- Forward speed of 2.1 km/h.
- Cutter-bar speed of 1.2 m/s.
- Cylinder speed of 2.5 m/s.
- Concave clearance of 9 mm.
- Straw walker speed of 0.12 m/s.
- Shoe speed of 0.5 m/s.

Grain moisture content of 2.5 %.

The ASAE Standard (1996) contains a list of machine efficiencies and range of traveling speeds. For combine harvesters, values of efficiencies in the range of 65-85 percent are usually obtained for machines operating speeds ranging between 3.34 - 6.68 km./h. These yield effective field capacities range from 0.22 to 0.56 hectares per hour per meter width of the machine. Awady et al. (1996) indicated that the best criteria of double action mower performance were: cutting efficiency ranging from 97 to 98 %, minimum heights of cut residue ranging from 2 to 3 cm, harvesting efficiency ranging from 85 to 96 %, machine productivity from 1.0 to 1.2 feddan./h, fuel consumption from 8.4 to 11.7 lit./h and power requirement from14 to 19 kWh/feddan for harvesting wheat and barely crops and cutting cotton stalks.

Morad (1997) indicated that the threshing losses of wheat crop as well as the threshing cost can be minimized when the feed rate of 1 ton/h, drum speed of 25 m/s, and moisture content of 20% are considered for the used machine. El-Behiry et al. (1997) studied the performance efficiency of some stationary threshing machines. He reported that the optimum operating conditions for threshing wheat were found to be 600 – 800 rpm for drum speed and 10 –12% straw moisture content to avoid the highest rate of the losses and grain damage. Nasr (2001) mentioned that the lower invisible seed damage was obtained at the optimum drum speed of 600 rpm, moisture content of 14%, feed rate of 1000 kg/h and 2.5 cm cylinder-concave clearance. Furthermore, the unthreshed seeds decreased with the increase of cylinder speed

The aim of this study is to adopt the suitable full mechanization method for barely crop with respect to energy requirements, costs of crop production and yield crop.

MATERIALS AND METHODS

The experiments were carried out at Nubaria site for producing barely crop (Giza-123 variety) during winter season of 2007. The previous summer crop was corn. The soil type was sandy clay loam (calcareous) and the average soil moisture content was about 17.8 % (d.b.). Some physical and chemical properties of the soil are summarized in table (1).

Table (1): Soil physical and chemical properties.

Experimental site	Soil fractions, %				Ca CO3, %	PH	Soil texture
	Coarse sand	Fine sand	Silt	Clay			
Nubaria	11.4	35.7	26.4	26.5	29.8	8.5	Sandy clay loam

Implement specification:

Implement specifications were summarized in Table (2).

Table (2): Some specifications of the used equipment.

Implement	Specifications
Tractor	Belarus 59.7 kW
Chisel plow	7 shanks in two rows, total width 175 cm
Rotary tiller	Total width 180 cm
Disc harrow	28-disc of 50 cm diameter 4 groups
Seed drill	20 rows, Tye, Shoe cutler, total width 3 m
Mower	Single knife 100 cm width
Thresher	Shams, drum diameter 73 cm and length 120cm. Concave has round holes 18 mm. The eccentric stroke of the screen is 3.5 cm
Combine harvester	Class 3 m cutting width, power 74 kW self-propelled

Treatments:

I-Tillage treatments:

Four different seedbed preparation systems were used: system1(chisel plow two passes + disk harrow one pass) , system 2 (chisel plow one pass + disk harrow one pass), system 3 (chisel plow one pass + rotary tiller) and system 4 (rotary tiller). Each treatment was repeated three times. The average plowing depth for chisel plow was 10 cm and the average plowing speed was 3.2 km/h.

Seed drill has been used for planting the soil. The traditional methods of fertilization and irrigation were applied for all treatments.

II- Harvesting methods.

The following two different mechanical harvesting methods were used:

1- Mechanical harvesting by mounted mower then threshing by thresher.

2. Combine harvester.

Harvesting losses determination:

Mower and combine header losses:

Mower and combine header losses have been measured by using two wooden frames 0.5 x 0.5 m one beside the other to determine losses. Three replicates were done for each test. The percentage of harvesting losses could be estimated as indicated in the following formula:

$$\text{Harvesting losses, } \% = \frac{Hg}{Tg} \times 100$$

Where:

Hg= Mower or combine header losses, kg/m²

Tg= Total grain yield, kg/m²

Mower and combine were operated at three different forward speeds of 2.1, 3.2 and 4 km/h.

Thresher losses:

Three different feed rates 0.75, 1.0 and 1.25 Mg/h with thresher. Thresher losses included damaged and unthreshed grains. It was calculated as follow:

$$\text{Threshing losses} = \frac{Dg + Un\,g}{Tg} \times 100,\ \%$$

Where: Dg = Weight of damaged grains collected at all outlets, kg.

Un g = Weight of unthreshed grain, kg.

Tg = Weight of total grain, kg.

Drum, straw walker and cleaning losses for combine harvester:

Grain dropped behind the combine were collected on plastic sheet and weighed, replications were done through the harvesting. Drum, straw walker and cleaning losses were calculated using the following equation:

$$\text{D, Sw losses} = \frac{D + Sw + C}{Tg} \times 100, \%$$

Where: D = drum losses, kg/m^2 Sw = straw walker losses, kg/m^2

C = cleaning losses, kg/m^2 Tg = total grain yield, kg/m^2

Yield:

Yield was recorded as a final target to evaluate tillage systems and harvesting operations. Three random samples were taken for each experimental plot. Wooden square frame (1 x 1 m) was used as a sampler to determine the yield.

Fuel consumption measurement:

Fuel consumption was measured to the nearest cubic centimeter using the fuel meter. The time for a certain volume of fuel consumed was recorded by using a stopwatch, from those two measurements the fuel consumption can be determined, Khadr (2004) and Khadr (2006) used the same instrumentation and the same method.

Actual field capacity (A.F.C):

Actual field capacity (A.F.C.) was calculated for each case by recording the actual operating time for mower and combine, ignoring transportation time.

$$\text{A.F.C.} = \frac{1}{\text{Total time in hour required per feddan}}, \text{ feddan/h}$$

Power determination:

The brake power is the best value to estimate the power needed for each implement that belongs to the different sources of power, like PTO power and drawbar power. The brake power could be estimated from the following equation:

$$\text{Thermal efficiency } (\eta_{th}), \% = \frac{P \times C}{\text{F.C.} \times \text{Fuel heating value (H.V)}} \quad \text{(Hunt 1983)}$$

Where:

(η_{th}) : fuel thermal efficiency, it is assumed to be 30%.

F.C.: fuel consumption, kg/h., P: brake power, kW.

H.V.: Fuel heating value, kJ/kg., C: constant = 3600.

Energy:

Energy could be estimated from both the power needed for operating the implement and the field capacity (feddan/h) or the feed rate (Mg/h).

The following formula was used to calculate the energy requirements for mower and combine:

$$\text{Energy requirements} = \frac{\text{Power(kW)} \times 3.6}{\text{Actual field capacity, feddan/h}} \quad \text{(MJ/feddan)}$$

Energy for thresher was calculated by the following equation:

$$\text{Energy} = \frac{\text{Power(kW)} \times 3.6}{\text{Feed rate, Mg/h.}}, \text{ MJ/Mg}$$

The human energy expenditure involved in the field operations can be estimated as a normal and healthy human labor supplies 0.1 hp (Chancellor, 1981).

Human energy (kW) = 0.1 x 0.746 x number of laborers

Cost analysis:

The cost of performing the different operations was estimated as a rent for the used machinery. The value of grain losses was considered; besides, the rented and the labor costs.

RESULTS AND DISCUSSIONS

Effect of seed-bed preparation on barley grain yield:

The average grain yield for all seedbed preparation systems under study is summarized in Table (3). The highest yield was 1.055 Mg/feddan with chisel plow two passes followed by disk harrow for one pass (system1). However, the lowest grain yield was 0.875 Mg/feddan. at seedbed preparation by using rotary tiller (system 4) .

Table (3): Treatments of seedbed preparation as effected on yield.

Seedbed preparation treatments	Yield, Mg./feddan.	Coefficient of variation, %	Standard deviation, kg/feddan
System1	1.055	5.5	58.025
System 2	0.980	6.2	60.76
System 3	0.929	5.6	52.024
System 4	0.875	4.9	42.875

Effect of tillage methods on energy requirements:

It is clear from Table (4) that the highest energy value was 76.86 MJ/feddan when using rotary tiller, while the other energy values were 38.23, 38.71 and 43.25 MJ/feddan when using chisel plow 2nd pass, disc harrow and chisel plow 1st pass respectively. the highest actual field capacity was 2.46 feddan./h when using the disc harrow. While, the lowest actual field capacity was 1.0 feddan./h when using rotary tiller.

Table (4): Fuel consumption, energy requirements and renting costs for seedbed preparation implement.

Implement	Fuel consumption, kg/h	Power, kW	Actual field capacity, feddan./h.	Energy, MJ/feddan.	Cost, LE/feddan.
Chisel 1st pass	5.75	20.06	1.67	43.35	26.4
Chisel 2nd pass	5.60	19.54	1.84	38.23	22
Disk harrow	7.58	26.45	2.46	38.71	22.36
Rotary	6.12	21.35	1	76.86	44.0

Harvesting operational losses:

As indicated in Fig. (1), mower and combine header grain losses increased by increasing harvesting speed, the highest grain losses for mower and combine header were 3.26 % and 3.64 % respectively at forward speed of 4.0 km/h, this may be due to the condition of the knives for mower and combine. Also, the speed and position of the reel for the combine. However, the lowest losses for mower and combine header were 1.97 and 2.37 % respectively at forward speed of 2.1 km/h.

Drum, straw walker and cleaning (D- Sw – C) losses for combine harvester:

The performance parameters of drum, straw walker and cleaning units are the percentage of detached and damaged seeds from threshing unit and separating the threshed seeds from straw (straw walker effectiveness) then to separate seeds from the chaff and other plant residues that have passed through the openings. Fig (2) shows that increasing harvesting speed increased total grain losses. The highest total grain losses was 7.51 % at forward speed 4.0 km/h, while the lowest total grain losses was 5.05 % at forward speed of 2.1 km./h. That because increasing the amount of plants inside the combine increase shattering loss (on the platform) and increase unthreshed grains.

Effect of feed rate on threshing losses for thresher:

Fig. (3) indicates that by increasing thresher feed rate from 0.75 to 1.25 Mg/h), at grain moisture content 12.7 % and drum speed 25 m/s, the total threshing losses (threshing losses, damaged grain and unthreshed grain) increased from 6.57 to 7.02 % and unthreshed grain from 0.98 to 1.95%. This may be attributed to the excessive barely plant in the threshing unit protecting grains from impacting with knives, while the damaged grain decrease from 2.14 to 1.41%.

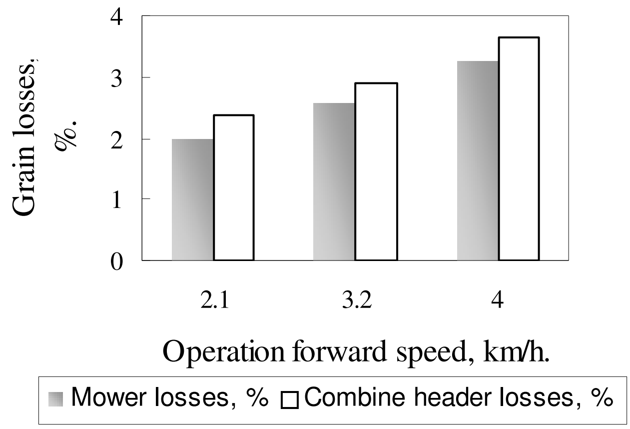

Fig. (1): Effect of forward speed on grain losses with mower and combine header.

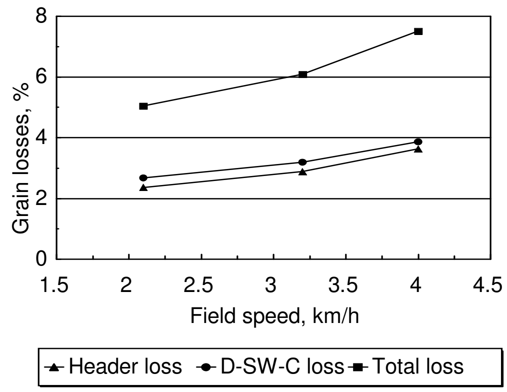

Fig. (2): Effect of forward speed on combine grain losses

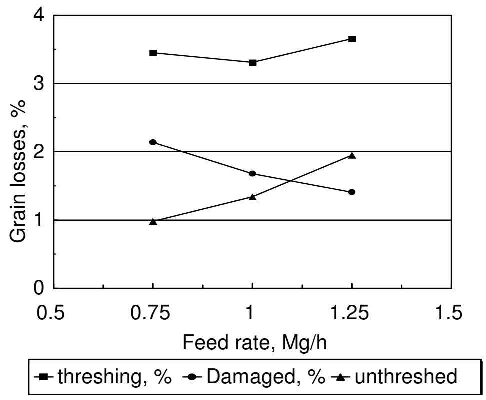

Fig. (3): Effect of feed rate on threshing losses, grain damaged and unthreshed grain at drum speed of 25 m/s.

Effect of seedbed preparation systems on costs:

The highest cost was 92.76 LE./feddan obtained by using system1 (Chisel plow two passes + disk harrow + seed drill) which gave the highest yield 1.055 Mg/feddan While, the lowest cost was 66 LE/feddan obtained by using system 4 (Rotary tiller + seed drill) which gave yield of 0.875 Mg/feddan, Table (5) shows the seed-bed preparation and planting cost.

Table (5): Total costs for seedbed preparation and planting barley.

Seedbed preparation and planting methods	Total cost, LE/feddan
Chisel plow two passes + disk harrow + seed drill	92.76
Chisel plow one pass + disk harrow + seed drill	70.76
Chisel plow one pass + rotary tiller + seed drill	92.4
Rotary tiller + seed drill	66

Effect of harvesting system on cost:

Total grain losses cost increased by increasing forward speeds in case of using mower and combine. Combine reduced the criterion cost of harvesting more than about three times with mechanical method (mower + binding + thresher). The criterion cost (operating cost + value of losses) of harvesting is presented in Table (6). Cost with the system of using (mower – binding and transfer – threshing) needs 127.40 LE/feddan. when using combine harvester cost was 132 LE/feddan.

Table (6): Operating and losses costs for different harvesting systems.

Harvesting system	Forward speed, km./h	Losses costs, LE./feddan	Operating cost, LE./feddan.	Criterion cost, LE./feddan
Mower, binding, transfer and thresher	2.1 3.2 4.0	198.02 204.25 211.63	127.40	325.42 331.65 339.03
Combine	2.1 3.2 4.0	53.28 64.57 79.23	132	185.28 196.57 211.23

*Price of one kg of barely is 1.0 LE
** Binding and transfer need 2-labor/feddan 10 LE each.
*** One feddan needs 3-hour for threshing, 4-labor for feeding, fee for one labor 4 LE. /h. and rent of the thresher 19.8 LE. /h.

Energy requirements:

It is clear from Table (7), that the energy required was 295.22 MJ/feddan when using mower, binding and transfer and threshing with a thresher machine; on the other hand, it was 87.21MJ/feddandan when using the combine harvester.

Table (7): Energy and costs requirements for some operating systems.

Implement	Fuel consumption, L./h	Power, kW	Act. field capacity, feddan./h.	Energy, MJ/feddan.
Seed drill	6.55	19.2	4.68	14.77
Mower	6.12	17.94	0.91	70.97
Binding and transfer	-	0.15	0.125	4.32
Thresher	6.88	20.16	0.33	219.93
Combine	11.82	34.64	1.43	87.21

CONCLUSION

The results showed that:

1- The least cost was 66 LE/feddan obtained by using system 4 for seedbed preparation and seeding with the seed drill, and the highest cost was 92.76 LE./feddan obtained by using system1 for seedbed preparation and seeding with the seed drill.

2- The highest energy was 76.86MJ./feddandan when using rotary tiller, but the other energy values were 38.23, 38.71 and 43.25 MJ./feddan when using chisel plow 2nd pass, disc harrow and chisel plow 1st pass at the depth of 10 cm.

3- The highest yield was 1.055 Mg./feddan with system 1 (chisel plow two passes+ disk harrow) comparing with system 4 (rotary tiller) which gave the least yield 0.875 Mg/feddan.

4- Increasing forward speed from 2.1 to 4.0 km/h the grain losses increased from 1.97 to 3.26 % for mower and from 2.37 to 3.64 % for the combine header losses. Also, total combine grain loss increased from 5.05 to 7.51 %.

5- Increasing thresher feed rate from 0.75 to 1.25 Mg/h at the previous moisture content and drum speed 25 m/s increased the total threshing losses (threshing losses, damaged grain and unthreshed grain) from 6.57 to 7.02 %.

6- Energy consumed and operating costs with the system of using (mower – binding and transfer – threshing) needed 295.22 MJ/feddan and 127.40 LE./feddan respectively; compared to energy consumed and operating cost only which were 87.21 MJ./feddan and 132 LE./feddan when using combine harvester.

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الملخص العربي

إختيار أنسب نظام لإعداد مرقد البذرة وطريقة الحصاد لإنتاج محصول الشعير في النوبارية

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أجريت هذه الدراسة بمنطقة النوبارية خلال الموسم الشتوي 2007 في أرض جيرية على محصول الشعير صنف جيزة 123. وتهدف هذه الدراسة إلي إختيار نظام مناسب لتجهيز الأرض والزراعة والحصاد للحصول على أعلى إنتاجية وربحية.

تمت التجارب الحقلية لمقارنة أربعة طرق لتجهيز الأرض وطريقة واحدة للزراعة و طريقتين للحصاد وذلك لتحديد تأثيرها على الإنتاجية.

طرق إعداد مرقد البذرة هي:

- محراث حفار وجهان متعامدين ثم استخدام مشط قرصي وجه واحد (نظام 1).
- محراث حفار وجه واحد ثم مشط قرصي وجه واحد (نظام2).
- محراث حفار وجه واحد ثم استخدام محراث دوراني (نظام 3).
- محراث دوراني (نظام 4).
- أجريت الزراعة الألية بالسطارة
- تم حساب متطلبات الطاقة لكل من الحرث بإستخدام المحراث الحفار وجه أول، و بإستخدام المحراث الحفار وجه ثاني، و بإستخدام المشط القرصي، بإستخدام المحراث الدوراني.

[1] باحث أول بمعهد بحوث الهندسة الزراعية
[2] باحث بمعهد بحوث الهندسة الزراعية

- تم دراسة طرق للحصاد والدراس الألي (الحصاد بالمحشة والدراس باستخدام آلة الدراس الثابتة وكذلك الكومباين للحصاد والدراس والتذرية في عملية واحدة).

- تم دراسة الطرق الألية للحصاد تحت تأثير ثلاث سرعات مختلفة 2.0، 3.2، 4.0 كم/ساعة للمحشة و الكومباين.
- تم دراسة فواقد الحبوب والحبوب المكسورة والتي لم يتم درسها بآلة الدراس تحت تأثير ثلاث معدلات تغذية مختلفة 0.75، 1.0، 1.25 ميجاجرام/فدان عند محتوى رطوبي 12.7 %.

<u>وقد أوضحت النتائج مايلي:</u>

- أعلى إنتاجية 1.055 ميجاجرام/فدان عند الحرث بمحراث حفار وجهين (عمق 10 سم) يتبعه مشط قرصي وجة واحد (نظام 1) والزراعة باستخدام السطارة بمعدل 55 كج /فدان.
- أقل انتاجية 0.875 ميجا جرام/فدان عند استخدام المحراث الدوراني (نظام 4)
- أعلي متطلبات للطاقة كانت 76.86 ميجاجول/فدان عند إستخدام المحراث الدوراني بينما كانت الطاقة 38.23، 38.71، 43.25 ميجاجول/فدان مع كل من المحراث الحفار وجهة ثانى، المشط القرصي، المحراث الحفار وجه أول علي الترتيب عند عمق 10سم
- بزيادة السرعة الأمامية من 2.1 آلي 4.0 كم/ساعة زاد فاقد الحبوب من 1.97 إلي 3.26 % في حالة الحصاد بالمحشة ومن 2.37 إلي 3.64% كفاقد الجزء الأمامي للكومباين (السكينة والمضرب) . وكذلك من 5.05 % إلي 7.51 % للفاقد الكلى للكومباين0
- فاقد حبوب لألة الدراس 3.47، 3.32 ، 3.7 % عند معدل تغذية 0.75 ، 1 ، 1.25 ميجا جرام على التوالى عند سرعة درفيل 25 متر/ث.
- متطلبات الطاقة للحصاد كانت 295.22 ميجاجول/فدان عند استخدام (الحصاد بالمحشة- التربيط- النقل- الدراس بآلة الدراس) بينما كانت 87.21 ميجاجول/فدان عند إستخدام الكومباين.
- أقل تكلفة كلية لتجهيز التربة والزراعة 66 جنية/فدان عند استخدام النظام 4 (المحراث الدوراني) ثم الزراعة بالسطارة بينما أعلي تكلفة تشغيل لإعداد مرقد البذرة والزراعة 92.76 جنية/فدان في حالة استخدام نظام 1 (محراث حفار وجهين ومشط قرصى) ثم الزراعة بالسطارة.
- أقل تكلفة كلية للحصاد (تكاليف تشغيل، فواقد في الحبوب) 185.28، 325.42 جنية/فدان باستخدام الكومباين & (محشة عند 2.1 كم/ساعة ، تربيط & نقل ، دراس) على التوالى عند سرعة أمامية 2.1 كم/ساعة.