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# PERFORMANCE EVALUATION OF A COMBINATION UNIT FOR PLANTING WHEAT IN SMALLHOLDINGS

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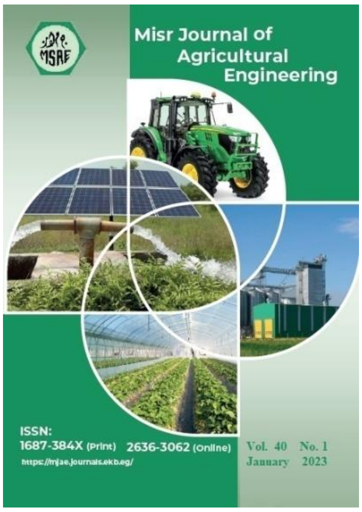


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**Keywords:**
Combination unit; Seed drill; Traditional method; Performance; Field efficiency; Required energy; Smallholdings; Economic return; Wheat.

**ABSTRACT**

*To select the proper method for wheat sowing operation. This research aims to evaluate the performance of a combined machine to planting wheat in smallholdings. The experiments were conducted at Faculty of Agriculture Farm, Fayoum University. Experimental area was divided into three main strips to received planting methods (combination unit, seed drill and traditional). Each strip received three forward speeds 4, 6 and 8 km h$^{-1}$. Treatments were combined in split plot design. Wheat seeds (Misr,1) planted in two seasons (2019/2020 and 2020/2021). Field capacity, field efficiency, theoretical energy required, wheat production and economic analysis were determined. Results indicated that the highest values of field efficiency were 73.74 and 81.76% and required energy were 61.84 and 32.63 kW h fed.$^{-1}$ for seed drill and combination unit respectively, at forward speed 4 km h$^{-1}$. The highest increases in wheat crop were 33.32% for grains and 15.66% for straw with seed drill, while it was 73.70% for grains and 30.54% for straw with combination unit at 6 km h$^{-1}$, compared to traditional method. Combination unit method at 8 km h$^{-1}$ gave the lowest values of total cost (16352.77 L.E. ha$^{-1}$). Combination unit method at 6 km h$^{-1}$ had the highest values of net return (31957.0 and 31314.7 L.E ha$^{-1}$) for first and second seasons, respectively. It can be recommend that using the combination unit with not increase the forward speed more than 6 km h$^{-1}$ to obtain best values of field capacity, field efficiency, required energy and net return of wheat crop.*

## 1. INTRODUCTION

The most important goals of combined machine are to find and test various new methods to seedbed preparation systems that can be applied for field crops resulting in more profit and soil conservation with less tillage operating **(Khalequzzaman and Karim, 2007)**. Agriculture machinery having an appositive impact on smallholders since they are efficient in accomplishing timely farm operations, reducing cost, and improving product **(Gauchan and Shrestha, 2017).**

The versatile strip seed drill is a unique, minimum-soil-disturbance multi-crop planter, and can be a platform on which to build conservation agriculture systems for small farm sizes (less than 1 ha) in Asia and Africa **(Haque et al., 2016)**.

Broadcasting method is suitable for saline, alkaline, and light soils but is not suitable for lands with a large number of weeds **(Tao et al., 2018)**. Seed drill recorded higher plant population (490 plants $m^{-2}$) and total biomass (12.66 Mg $ha^{-1}$) while manual broadcasting and ridging recorded higher grains t yield (3.63 Mg $ha^{-1}$) **(Ahmed, 2006)**. The forward speed of 2.18 km $h^{-1}$ gave grains yield of wheat 8.21 and 8.36 Mg $ha^{-1}$, and the otherwise forward speed of 5.46 km $h^{-1}$ gave 7.48 and 7.64 Mg $ha^{-1}$ for mechanical and pneumatic seed-drill, respectively **(El-Awady et al., 2000)**. Experts recommend the drill method, which is convenient for mechanization and cost-saving, improves wheat population structure and yield **(Tao et al., 2018).**

Reducing number of passes and using combined equipment is getting popular due to their effect on efficiency, time, and costs **(Javadi and Hajiahmad, 2006)**. The standard rotary tillage seed drill has been modified, seed placement has been enhanced by the incorporation of superior tine openers. It can be used as a 100% tillage implement, or as a strip-tillage seed drill **(Hossain et al., 2009)**. Rotational tillage causes break and mix the soil by using the tractors power and the operation typically require only one pass to let the soil is ready for planting **(Valainis et al., 2014).**

Using the combination unit as minimum tillage, the forward speed must not increased more than 3.5 km $h^{-1}$ in clayey soils, to saved about 58% of the required operating time on preparation and wheat planting **(Imbabi, 2001)**. Using the combination unit at a forward speed of 4 km $h^{-1}$ and a working depth of 12 cm to improve soil physical properties **(Morad et al., 2001)**.

No-tillage drill was the most time, energy, and cost-effective for 70%, 67%, and 6%, respectively, over the traditional practice **(Ali, 2009)**. The bed planting seed drill cut down the time for wheat seeding operation by about 42% **(El-Awad and Mohamoud, 2010).** The creation of combined till-plant machine is caused by high demands on the quality of pre-sowing tillage and the need to reduce the time gap between tillage and seed sowing. It is recommended to use combined till-plant more widely to save fuel and labor costs **(Gaidenko and Kernasyuk, 2014).** Economical evaluation of the seed drill use indicates the reduction in fuel and lubricants consumption per hectare of about 20%, in comparison with traditional method **(Arifa and Oleh, 2018)**.

The effective field capacity of the drill increased by 19% and fuel consumption was reduced by 21% compared to traditional plowing (**Hossain et al., 2012). Quasim et al. (2019)** indicated that the zero-till-slit seed drill showed higher field capacity, higher field efficiency, and lower fuel consumption compared to the combined tillage and seeding equipment. **Omar et al. (2021)** found that the lowest energy per unit of production was 20.7 kW h $Mg^{-1}$ with using modified seed drill under chisel plough (2 passes).

Wheat (*Triticum aestivum L.*) is one of the most important cereal crops in the world. It is the main staple food of nearly 35% of the world population than any other food source. Wheat is a rich source of protein, minerals, and vitamins amongst all the cereals **(FAO, 2017).** The yield of wheat crop was 3.39 Mg $ha^{-1}$ in the worldwide **(USDA, 2017).** The Egyptian annual wheat cultivated area is about 1.30 million ha, producing 8.6 Tg of grains (**EMALR, 2020)**.

Applying the bandwidth distributor to perform wheat sowing, and using the rotary tiller followed by a lever to perform grain covering operation lead to increase the number of plants per $m^2$ (347.60) and provided the heights crop grain yield (6.748 Mg $ha^{-1}$) **(Abo-EL-Naga et al., 2009)**. The yield of wheat under mechanization (2.65 Mg $ha^{-1}$) is higher than that of traditional farms (2.57 Mg $ha^{-1}$). The total variable cost is significantly higher for traditional farms **(Rahman et al., 2011)**. The drilling sowing method gave the highest values of number of grains per spike **(El-Ashmouny et al., 2016)**. The highest yield of wheat was 3.548 Mg $ha^{-1}$ and obtained at minimum tillage and where a power tiller operated seed drill machine was used for wheat cultivation, and this yield was more than 10% higher than farmer's practices **(Jha et al., 2019)**. The wheat productivity increased by 15.6 and 24.5% when sowing with drill on raised bed and drill on surface compared to the manual broadcasting, respectively **(Omar and Abdel-Hamid, 2021)**.

The optimum distance was 30 cm to achieve a higher seed yield of 1.941 Mg $ha^{-1}$, lower energy of 17.24 kW.ha $Mg^{-1}$, the production cost of 26.44 L.E $Mg^{-1}$, and higher field efficiency of 89.41% at a forward speed of 3.13 km $h^{-1}$ **(Afify, 2009)**. In smallholding area (2 ha), the costs of tillage and sowing are highest. If the farm size increased to 20 ha, the costs in different tillage and sowing systems decreased by 12 to 27% $ha^{-1}$ **(Sarauskis et al., 2012)**.

The cost of operation and energy requirement for cultivator-cum-seed drill was found Rs 591 $ha^{-1}$ and 320.58 MJ $ha^{-1}$ **(Verma and Guru, 2015)**. The average results for overlapped seed broadcasting were higher than those of the traditional manner by: 0.8%, 0%, 3.3%, 6.7%, and 14.5% for fuel consumption, working time, energy utilization, wheat yield, and total cost, respectively **(Khurshid and Sedeeq, 2019)**.

This study aims to evaluate the performance of combination unit machine used in planting smallholdings and the economic return of wheat crop.

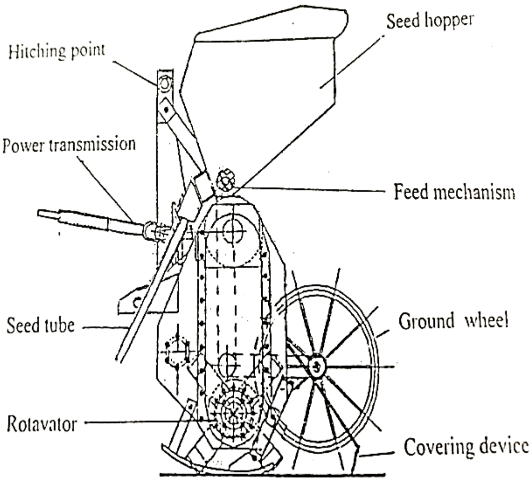
## 2. MATERIALS AND METHODS

Description of agricultural equipments and measuring instruments:

**a- Agricultural equipments:**

1. Tractor: Made in Russia, Belarus 92, (D243.1), direct fuel injection, diesel 4 cylinders. Engine (Hp) 67.65 KW at 2200 rpm.
2. Seed drill machine: American made, Model (104-4270), working width (3 m), number of tubes (21), raw spacing (15 cm), and seed box capacity (150 kg).
3. Combination unit machine: The combination unit machine consisted of two parts: a). Rotary tiller with 6 blades, each blade contains 4 tines arranged in alternate directions, b). The seeder which seed broadcasting process, the effective width 120 cm, and the number of seed tubes 8. It is a simultaneously performs tillage (depth is 12.5 cm) and planting operations. The machine was fabricated in the Factory of 999 El-Harby with 100% locally available materials. It's dimensions were as follow: total length of 100 cm, total

width of 160 cm, width of seed box of 127.5 cm, and diameter of ground wheel of 60 cm., and seed box capacity (75 kg). The total weight is 500 kg.




**Combination unit machine**

4. Self-propelled mower: Made in Italia, Model (Ferrari 702, 2 wheel drive), Type (Front - mounted mower), Hp (9.56 KW), working width of cut (120 cm),
5. Chisel plough: Locally made (Behera Co.), 7 tines, working width of 175 cm.
6. Forward speed of tractor measurement: three treatments of forward speeds of tractor were done, e.g., 4, 6 and 8 km $h^{-1}$. The forward speed was determined by global position system apparatus (GPS), and also, by velocity gauge in the tractor. The velocity of tractor was constant from the beginning to the end of track.
7. Track and turn time measurement: A common stop watch with 0.5 second accuracy was used in measuring the time from the beginning to the end of the track or turn.

**Methods and measurements:**

**a). Location and site preparation**

Field experiments were conducted at Demo Farm, Faculty of Agriculture, Fayoum University, Fayoum, Egypt, the coordinates of experiments location are 29° 17ˋ 34.1˝N and 30° 54ˋ 54.3˝ E. The soil texture is sandy loam. Soil samples were taken from the experimental soil before planting. Some initial physical and chemical characteristics were determined, according to the methods and procedures outlined by **Klute (1986)** and **Page et al. (1982)** (Table, 1).

The field experimental area was 1.47 ha and divided into three main strips to conduct three planting methods e.g., combination unit, seed drill and manual broadcasting (traditional method). Each main strip (33.3 m of width × 154 m of length) was divided into three sub-main strips to conduct three forward speeds of tractor (4, 6 and 8 km $h^{-1}$). The treatments were combined in a complete randomized block design in split plot with three replicates (**Snedecor and Cochran, 1980)**. The strips that will be used in traditional or seed drill planting methods were tilled (two passes by chisel plow) before planting process. While, the strip that will be used in combination unit planting method was not tilled before planting process.

All treatments were planted by wheat seeds (*Triticum aestivum* L., cultivar Misr$_1$) in two winter seasons (2019/2020 and 2020/2021) with seed rate of 142.86 kg ha$^{-1}$.

Square wooden frame, dimensions of 100 cm ×100 cm, used in measuring the number of plants in m$^2$ after 15 day of planting. After harvesting, some growth parameters and wheat crop production e.g., plant height (cm), spike weight (g m$^{-2}$), 1000 grains weight (g), straw weight of wheat plants (t ha$^{-1}$), and grains weight of wheat crop (t ha$^{-1}$) were determined for each treatment.

**Table (1). Some initial physical and chemical soil properties of the experimental (as mean values of two seasons).**

| **1- Soil physical properties** | | | |
|---|---|---|---|
| Particle size distribution | Soil depth (cm) | | |
| | 0–15 | 15–30 | 30-45 |
| Sand, % | 67.53 | 69.38 | 71.54 |
| Silt, % | 17.81 | 16.79 | 15.92 |
| Clay, % | 14.66 | 13.83 | 12.54 |
| Texture class | SL* | SL | SL |
| Dry bulk density (g cm$^{-3}$) | 1.50 | 1.56 | 1.62 |
| Total porosity, % | 43.18 | 41.13 | 38.87 |
| **2- Soil chemical properties** | | | |
| pH (in soil-paste) | 7.43 | 7.45 | 7.60 |
| ECe (dS m$^{-1}$) in soil paste extract | 3.10 | 3.37 | 3.62 |

* SL is sandy loam soil.

The calibration process of combination unit was conducted to ensure that the machine, when operating, would drop the specified amount of wheat seeds (kg ha$^{-1}$). The quantity of calibrated seeds calculated by the following equation:

$$\text{Amount of wheat seeds (kg ha}^{-1}\text{)} = \frac{\textbf{Fallen wheat seeds } (\boldsymbol{kg}) \times \textbf{ 10000}}{\textbf{Calibration area (m2)}} \times \textbf{1.1}$$

Where: calibration area = running width (m) × wheel circumference (m) × number of runs during calibration.

The seeds metering mechanism was controlled by increasing or decreasing (by moving the key) according to the result and its relation to the appropriate rate of wheat seeds.

Self-propelled mower used in the first season to wheat harvesting. While, in the second season hand sickle used to harvesting.

**b). Performance rate:**

1. Theoretical field capacity (TFC) (ha h$^{-1}$): was determined for the combination unit and seed drill machines using the following equation according to **Kepner et al. (1982):**

$$\text{TFC} = 0.10 \text{ W . S}$$

2. The actual field capacity (AFC) (ha h$^{-1}$): was calculated by using the following equation according to **Kepner et al. (1982):**

$$\text{AFC} = \frac{1}{T_t}$$

3. Fuel consumptions measurement: To measure the fuel consumption, the connection between the fuel tank and the engine in the tractor was separated. A liter capacity (1000 ml) graduated cylinder was used to measurement the fuel consumption after fixed beside the tractor engine. A below side hole was made in the graduated cylinder and it was connected to the tractor engine immediately by clear plastic pipe. The graduated cylinder was filled with fuel and the fuel reading was taken of the cylinder at the end of each track, and also at the end of each turn time.

4. Field efficiency, (%): calculated by using the following equation according to **Kepner et al. (1982):**

$$F_e\% = \frac{AFC}{TFC} \times 100$$

**c). Theoretical energy required, ( $E_r$):**

The theoretical energy required was calculated by using the following Equation according to **(Embaby, 1985)**:

$$E_r = C_f \times \frac{1}{60 \times 60} \times \rho_f \times C.V \times 427 \times \frac{1}{75} \times \frac{1}{1.36} \times Tt, \quad kw.\ h\ fed^{-1}$$

**d). Cost analysis:**

The operating costs were calculated according to **(Younis, 1997)**.

**e).** The results were statistically analyzed using SPSS computer method according to **Gomez and Gomez (1984)**. Least significant difference method (LSD) was used to differentiate means at the 0.05 level.

## 3. RESULTS AND DISCUSSION

**1. Effect of tractor forward speed on the operation performance for seed drill and combination unit**

**a). Track and turn time values:**

Figure (1) shows the effect of tractor forward speed on track and turn time values (as mean values of two seasons) for seed drill and combination unit. The highest values of track and turn time were 3.38 and 3.08 h $ha^{-1}$ with seed drill and combination unit machines, respectively, at forward speed 4 km $h^{-1}$. The high values of track and turn time with seed drill method may be due to increasing soil resistance to penetration during planting. While, the lowest value of track and turn time was 1.76 h $ha^{-1}$ under combination unit at the forward speed 8 km $h^{-1}$. The lowest value of track and turn time may be due to the lack resistance countered by the combination unit during its soil agitation. Based on the foregoing and with a presence of significant differences, which can be arranged the track and turn time values in ascending order as follows: combination unit < seed drill machine.

**b). Track and turn fuel consumption:**

Figure (2) shows the effect of tractor forward speed on track and turn fuel consumption values (as mean values of two seasons) for seed drill and combination unit. The track and turn fuel consumption values were low with combination unit as compared to seed drill at all the forward speeds of tractor (4, 6 and 8 km $h^{-1}$). The decreases in track and turn fuel consumption values with combination unit may be due to the forward rotational movement of the rotary tiller blades attached to the machine moves forward and in the same direction as the movement of tractor which helps to push the machine or advance it forward, with low or no soil resistance to it.

The highest values of track and turn fuel consumption were 17.53 and 13.84 liter $ha^{-1}$ with seed drill and combination unit, respectively, and they were recorded at forward speed 4 km $h^{-1}$.

The high decreases in the values of track and turn fuel consumption at forward speed 8 km $h^{-1}$ attributed to the decreasing in the track and turn time values as compared with forward speeds of tractor 4 and 6 km $h^{-1}$, this because the reduction in the time required to complete track and turn.

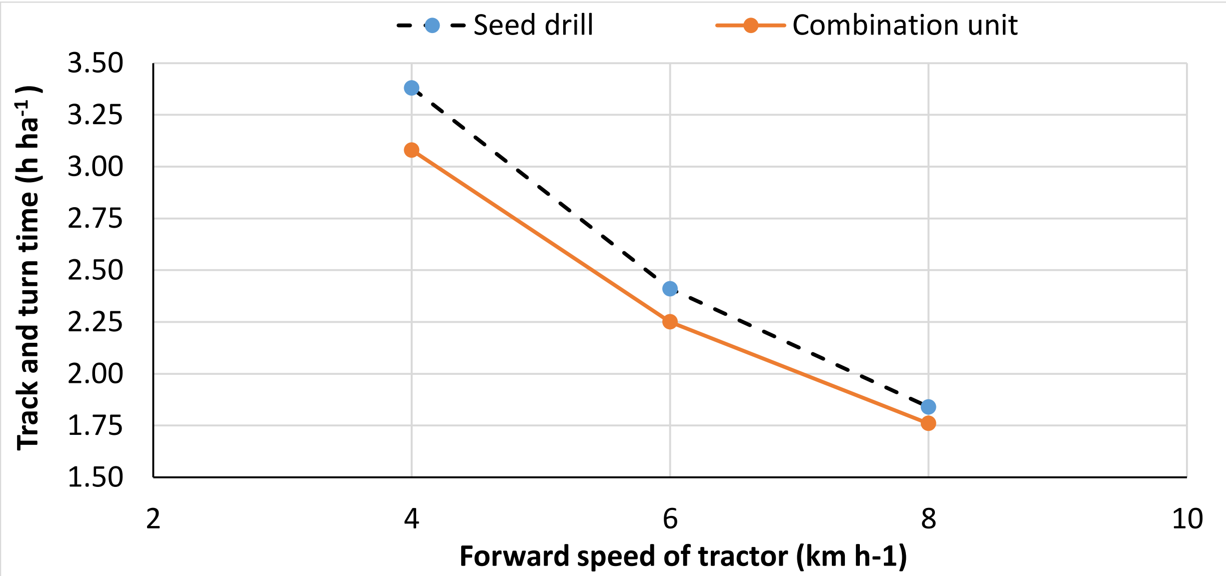



**Fig. (1). Effect of tractor forward speed on track and turn time values (h $ha^{-1}$) (as average values of two seasons) for seed drill and the combination unit.**

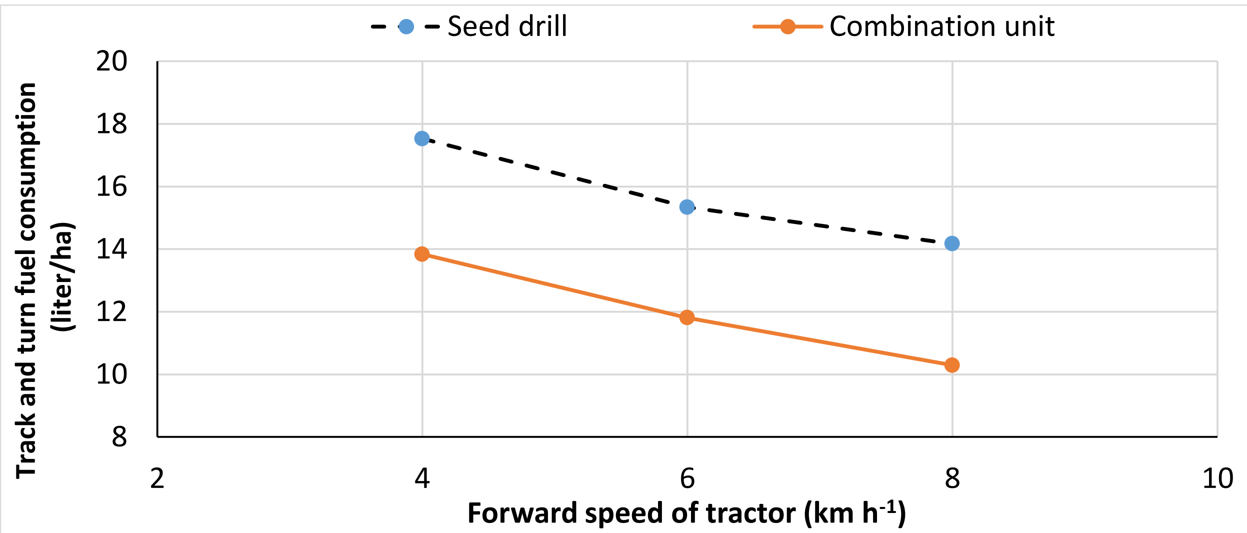



**Fig. (2). Effect of tractor forward speed on track and turn fuel consumption (liter $ha^{-1}$) (as average values of two seasons) for seed drill and the combination unit.**

**c). Theoretical and actual field capacity:**

Figures (3 and 4) show the effect of tractor forward speed on the theoretical and actual field capacity values (as mean values of two seasons). Results indicated that, under seed drill and combination unit planting methods, theoretical and actual field capacity values were increased with increasing the forward speeds of tractor from 4 to 6 and 8 km $h^{-1}$. These results are compatible with those found by **Sarhan et al. (2010).** The theoretical and actual field capacity values were low with the combination unit as compared to seed drill method at all the forward speeds of tractor (4, 6 and 8 km $h^{-1}$).

These decreases attributed to the working width of the combination unit machine was low (1.2 m) as compared to the seed drill machine (3 m), in addition to, the lowest actual time consumed was obtained with rotary tiller in combination unit.

The highest values were 2.40 and 0.96 ha $h^{-1}$ for theoretical field capacity and were 1.65 and 0.67 ha $hr^{-1}$ for actual field capacity with seed drill and combination unit, respectively, and they recorded at forward speed 8 km $h^{-1}$ (as mean values of two season). The increases in theoretical and actual field capacity values with seed drill may be due to the decreasing in the time for planting operation. Also, these results were agreement with those obtained by **Dharmendra et al. (2022).**

The lowest values of theoretical and actual field capacity were 0.48 and 0.40 ha $h^{-1}$ respectively, under combination unit at forward speed 4 km $h^{-1}$. The decreasing in these values may be attributed to decreased working width of the combination unit machine. Based on the presence of significant differences, which can be arranged the theoretical and actual field capacity values in ascending order as follows: combination unit < seed drill machine.

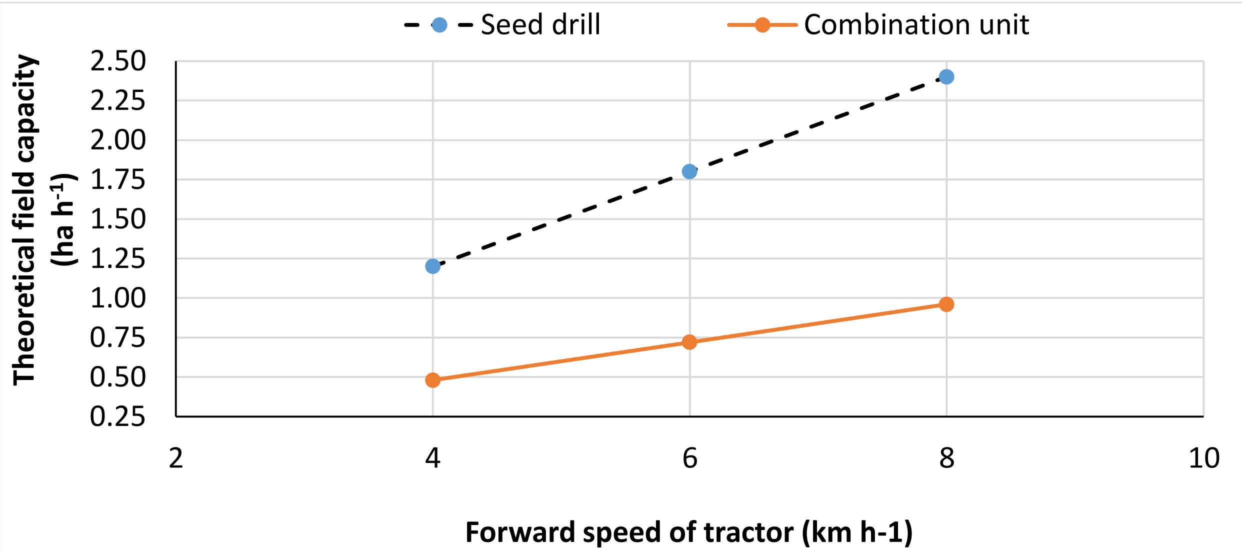



**Fig. (3). Effect of tractor forward speed on the theoretical field capacity (ha $h^{-1}$) (as mean values of two seasons) for seed drill and the combination unit.**

**d). Field efficiency:**

Figure (5) shows the effect of tractor forward speed on the field efficiency values (as mean values of two seasons). The field efficiency values were significantly decreased when the forward speeds of tractor increased from 4 to 6 and 8 km $h^{-1}$ under seed drill and combination unit planting methods. The decreasing in the field efficiency values at high forward speed may be due to increasing rate of theoretical field capacity more than the increasing rate of actual field capacity.

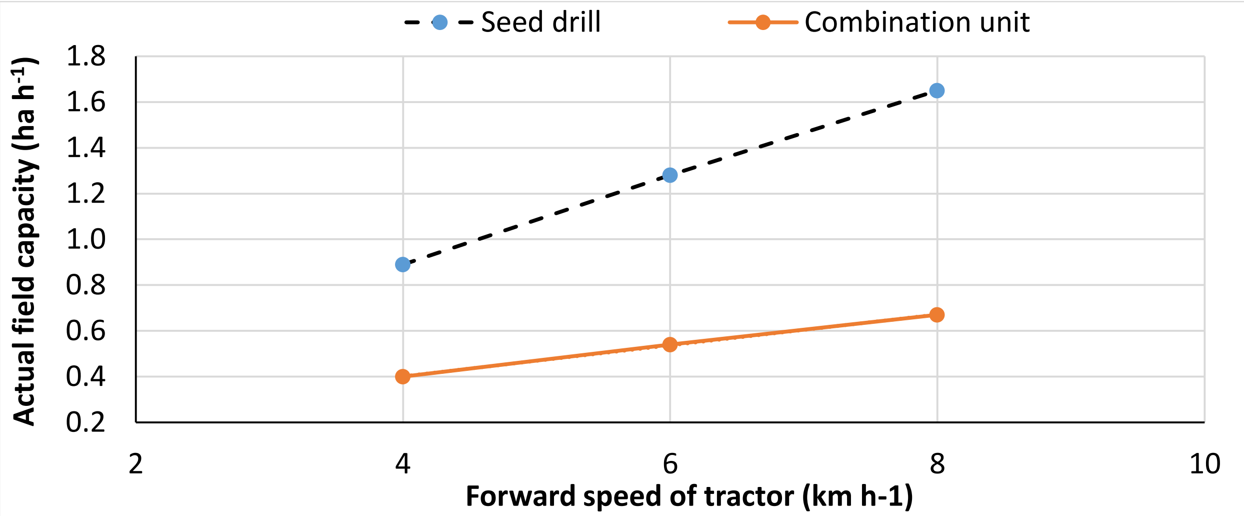



**Fig. (4). Effect of tractor forward speed on the actual field capacity (ha $h^{-1}$) (as mean values of two seasons) for seed drill and the combination unit.**

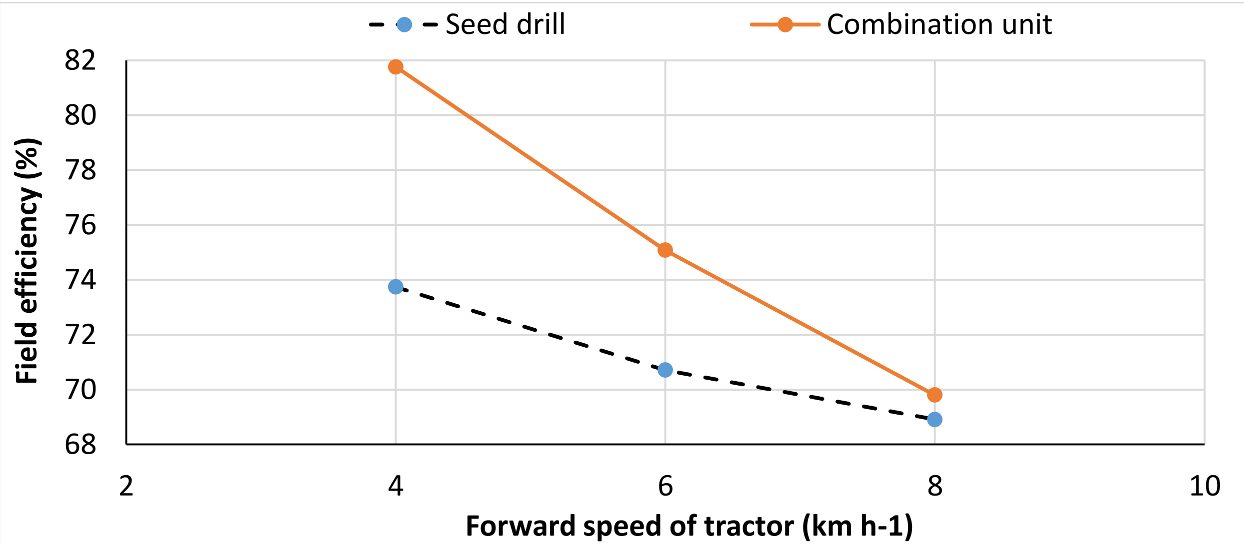



**Fig. (5). Effect of tractor forward speed on the field efficiency (%) (as mean values of two seasons) for seed drill and the combination unit.**

On the other hand, the field efficiency values were high with combination unit planting method as compared to seed drill planting method at all forward speeds of tractor (4, 6 and 8 km $h^{-1}$).

The increases in the field efficiency values with combination unit machine may be due to it had a small working width, and reduction in track and turn time losses. These results were agreement with those conducted by **Jithender et al. (2017).** The highest values of the field efficiency were 73.74 and 81.76% with seed drill and combination unit planting methods, respectively, and they were recorded at forward speed 4 km $h^{-1}$ (as mean values of two seasons). The high value of field efficiency with combination unit method at forward speed 4 km $h^{-1}$ may be attributed to decreasing in the actual field capacity values.

While, the lowest values of field efficiency were 68.91 and 69.80 % with seed drill and combination unit planting methods, respectively, and they recorded at forward speed 8 km $h^{-1}$ (as mean values of two season). Based on the significant differences, which can be arranged the field efficiency values in descending order as follows: combination unit > seed drill machine.

**e). Theoretical energy required:**

Figure (6) shows the effect of tractor forward speed on the required energy values (as mean values of two seasons). Results indicate the theoretical energy required values were significantly decreased with increasing the forward speeds of tractor from 4 to 6 and 8 km $h^{-1}$ under seed drill and combination unit planting methods due to decreasing in the required time to complete the planting process at the high forward speed 8 km $h^{-1}$.

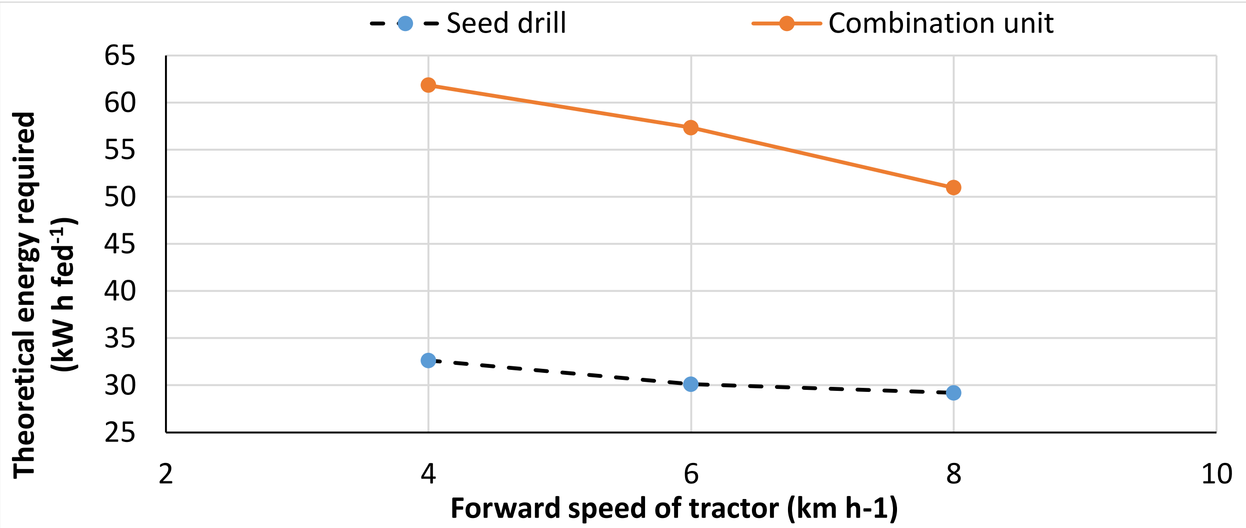



**Fig. (6). Effect of tractor forward speed on the theoretical energy required values (kW. h fed.$^{-1}$) (as average values of two seasons) for seed drill and the combination unit.**

The highest values of the required energy were 61.84 and 32.63 kW h $fed^{-1}$ with seed drill and combination unit planting methods, respectively, and they recorded at forward speed 4 km $h^{-1}$ (as mean values of two season). The high value of theoretical energy required with combination unit method at forward speed 4 km $h^{-1}$ may be due to the time completing for planting process with combination unit was more than twice the time that it takes with seed drill. In addition to, this is because the working width of combination unit machine is (1.2 m), while in the seed drill machine is (3 m). It can be arranged the values of theoretical energy required in descending order as follows: combination unit > seed drill machine. These results were agreement with those found by **Mohamed (2016).**

**2. Effect of tractor forward speed on some growth parameters, and yield production of wheat crop**

**a). Some growth parameters of wheat crop:**

Figure (7) shows the effect of planting methods and different forward speeds of tractor on some growth parameters of wheat plants (as mean values of two seasons). The highest values of plant height, number of wheat plants $m^{-2}$ and spikes weight were 101.73 cm, 285.8 and 954.7 g and they recorded at forward speed 6 km $h^{-1}$ with combination unit method. These values were higher with combination unit planting method than with seed drill or traditional planting methods, these may be due to the combination unit machine resulted a good soil physical properties at forward speed 6 km $h^{-1}$.

In addition, Figure (7) indicates the plant height values of wheat increased by 11.40, 12.16 and 6.76% with seed drill and by 18.14, 19.26 and 5.45% with combination unit planting method at forward speeds of tractor 4, 6 and 8 km $h^{-1}$, respectively, as compared to traditional planting method.

The number of wheat plants per $m^2$ values increased by 17.67, 29.73 and 0.16% with seed drill planting method and by 105.99, 122.41 and 77.35% with combination unit planting method at forward speeds of tractor 4, 6 and 8 km $h^{-1}$, respectively, as compared to traditional planting method.

Also, the spikes weight values of wheat crop increased by 14.67, 16.00 and 7.39% with seed drill planting method and by 60.55, 62.14 and 22.92% with combination unit planting method at forward speeds of tractor 4, 6 and 8 km $h^{-1}$, respectively, as compared to traditional planting method.

The highest values of the above-mentioned growth parameters of wheat plants were recorded with the combination unit planting method, due to this machine have a rotary tiller which resulted in a good disintegrate and good seedbed preparation of surface soil layer at forward speed 6 km $h^{-1}$ as compared to speeds 4 and 8 km $h^{-1}$. All mentioned growth parameters of wheat plants are improved at forward speeds of tractor as the descending order: 6 > 4 > 8 km $h^{-1}$.

**b). Yield of wheat crop:**

Figure (8) shows the effect of tractor forward speed on wheat crop production (as mean values of two seasons). With seed drill and combination unit planting methods, the values of 1000 grains weight, straw and grains weight of wheat crop were significantly increased at all forward speeds of tractor 4, 6 and 8 km $h^{-1}$ as compared to traditional planting method.

The highest values of 1000 grains weight, straw weight and grains weight of wheat crop were 49.67 (g), 12.668 (Mg $ha^{-1}$) and 6.557 (Mg $ha^{-1}$), respectively, and were recorded at forward speed 6 km $h^{-1}$ with combination unit planting method. On the other hand, the lowest values of the above-mentioned parameters were 45.28 (g), 9.704 (Mg $ha^{-1}$) and 3.775 (Mg $ha^{-1}$), respectively, and they recorded with traditional planting method. These results are agreement with those conducted by **Rahman et al. (2011)**.

Also, Figure (8) indicates the values of 1000 grains weight increased by 4.84, 5.85 and 2.52% with seed drill and by 8.88, 9.70 and 4.53% with combination unit at forward speeds of tractor 4, 6 and 8 km $h^{-1}$, respectively, as compared to traditional planting method.

The values of straw weight of wheat crop increased by 14.62, 15.66 and 4.48% with seed drill and by 29.86, 30.54 and 13.12% with combination unit at the forward speeds of tractor 4, 6 and 8 km $h^{-1}$, respectively, as compared to traditional planting method.

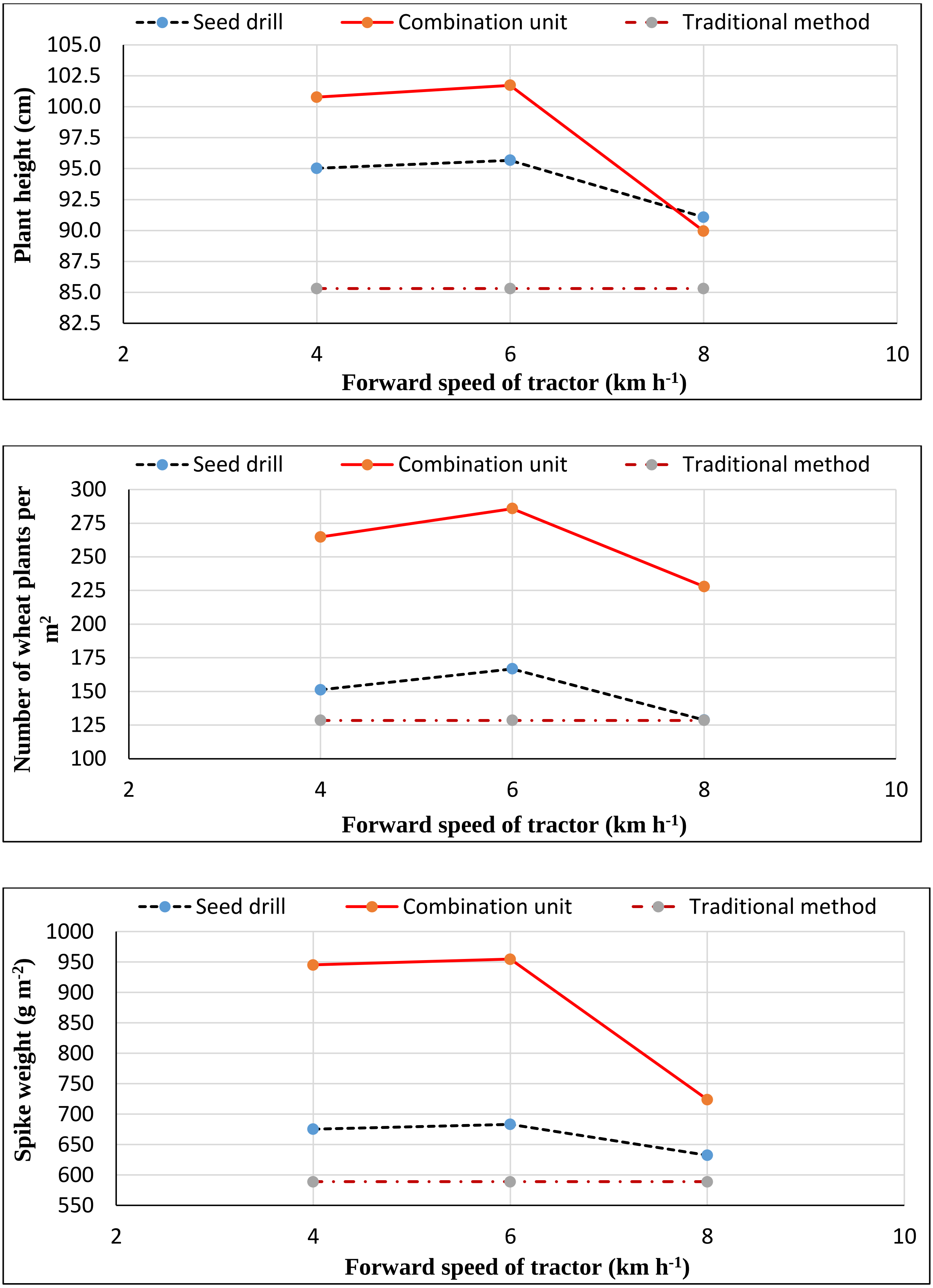



**Fig. (7). Effect of tractor forward speed on some growth parameters of wheat plants (as mean values of two seasons).**

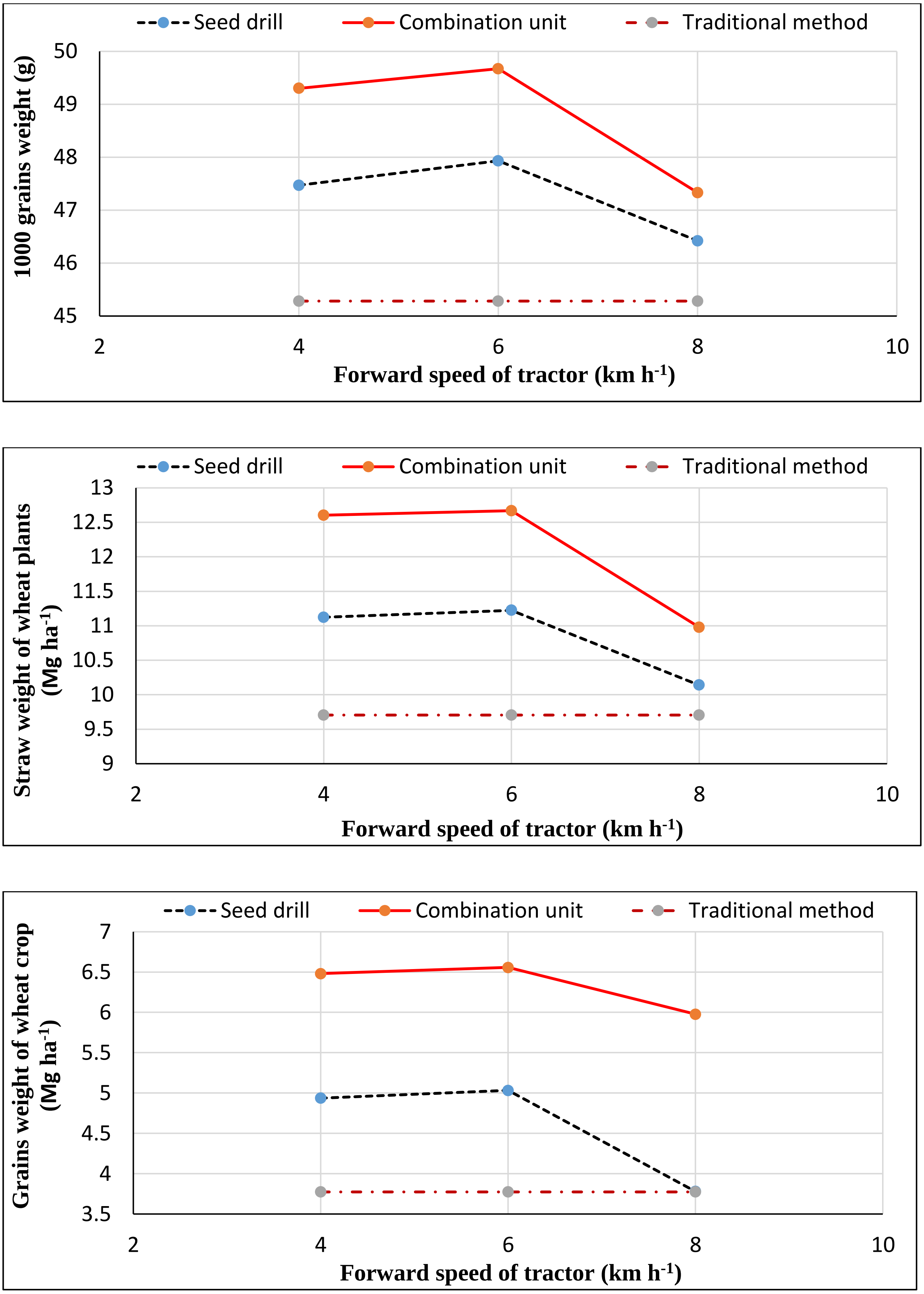



**Fig. (8). Effect of tractor forward speed on yield and yield quality of wheat plants (as mean values of two seasons).**

Also, the values of grains weight of wheat crop increased by 30.78, 33.32 and 0.13% with seed drill and by 71.66, 73.70 and 58.33% with combination unit at the forward speeds of tractor 4, 6 and 8 km $h^{-1}$, respectively, as compared to traditional planting method.

The above mentioned results indicated that, under seed drill and combination unit planting methods, crop yield of wheat are improved at forward speed of tractor as the descending order: 6 > 4 > 8 km $h^{-1}$, and This may be due to occurring an improvement in the soil physical properties and wheat plant growth parameters at forward speed 6 km $h^{-1}$. Under seed drill and combination unit planting methods, the results indicated that the increases in the values of wheat crop yield are nearly similar at forward speeds of tractor 4 and 6 km $h^{-1}$.

**3. Economic return as affected by planting methods and forward speed of tractor**

Table (2) shows the effect of tractor forward speed on cost analysis and economic return. The last two columns of table (2) shows that the order of preference for all planting methods according to the least cost per hectare and according to the highest return for each Egyptian pound spent in wheat crop production.

The combination unit planting method at the forward speed 8 km $h^{-1}$ was the best method with respect to wheat crop production costs, since it was 14657.27 and 18047.66 L.E. $ha^{-1}$ for the first season and the second seasons, respectively. The traditional planting method was the last method, since wheat crop production highest costs reached 16554.25 and 20000.39 L.E. $ha^{-1}$ for the first and the second seasons, respectively. Combination unit method at 6 km $h^{-1}$ had the highest values of net return (31957.0 and 31314.7 L.E. $ha^{-1}$) for first and second seasons, respectively. According to the $C_2/C_1$ ratio {(free market price ($C_2$) L.E. $Mg^{-1}$ / cost ($C_1$) L.E. $Mg^{-1}$}, combination unit planting method at forward speed 6 km $h^{-1}$ was found to be the best method, since it had the highest $C_2/C_1$ ratio, 3.16 and 2.73 for the first and the second seasons, respectively.

## 4. CONCLUSIONS

It appears from the effect of tractor forward speed on field capacity, field efficiency and theoretical energy required values, it can be arranged in the descending order: combination unit > seed drill machine. Also, growth parameters and wheat crop production values can be arranged in the descending order: combination unit > seed drill machine > traditional method. The difference, whether it was an increase or a decrease which resulted of the effect forward speeds of tractor 4 and 6 km $h^{-1}$ of all the studied traits is small and not significant. It can be recommend that using the combination unit to planting wheat crop in smallholdings as a minimum tillage and with not increase the forward speed more than 6 km $h^{-1}$ to obtain the best values of field capacity, field efficiency, theoretical energy required, wheat yield production and economic net return of wheat crop.

**Table (2). Effect of tractor forward speed on cost analysis and net return of wheat crop production under the first and second seasons.**

| Season | Planting Method | Forward speed, km $h^{-1}$ | Operation cost, L.E. $ha^{-1}$ | | | | | | | | Total costs, L.E. $ha^{-1}$ | Yield (grains & straw) Mg $ha^{-1}$ | Cost per Mg, ($C_1$) L.E. Mg | Free market price ($C_2$) L.E. Mg | Net return (L.E. $ha^{-1}$) | $C_2/C_1$ Ratio | Order of preference | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Chisel lough (1st pass) | Chisel lough (2ed pass) | Manual planting | Mechanical seeding | Irrigation | Fertilizing | Manual harvesting | Mechanical threshing | | | | | | | Acc. to cost $ha^{-1}$ | Acc. to return / cost |
| $1^{st}$ season | Trad. | - | 510.38 | 342.84 | 1536.17 | - | 3869 | 7383 | 837.86 | 2075 | 16554.25 | 13.459 | 1229.976 | 2191.7 | 12943.8 | 1.78 | 7 | 7 |
| | Seed drill | 4 | | | | 484.09 | | | | | 15502.17 | 16.453 | 942.209 | 2319.7 | 22663.9 | 2.46 | 6 | 5 |
| | | 6 | 510.38 | 342.84 | - | 356.22 | 3869 | 7383 | 837.86 | 2075 | 15374.30 | 16.633 | 924.325 | 2329.0 | 23364.0 | 2.52 | 5 | 4 |
| | | 8 | | | | 269.45 | | | | | 15287.53 | 13.817 | 1106.429 | 2196.7 | 15064.3 | 1.99 | 4 | 6 |
| | Comb. unit | 4 | | | | 814.48 | | | | | 14979.34 | 18.960 | 790.050 | 2447.6 | 31427.2 | 3.10 | 3 | 2 |
| | | 6 | - | - | - | 631.77 | 3869 | 7383 | 837.86 | 2075 | 14796.63 | 19.087 | 775.220 | 2449.5 | 31957.0 | 3.16 | 2 | 1 |
| | | 8 | | | | 492.41 | | | | | 14657.27 | 16.863 | 869.197 | 2514.6 | 27746.4 | 2.89 | 1 | 3 |
| $2^{nd}$ season | Trad. | - | 510.38 | 342.84 | 1536.17 | - | 3869 | 7383 | 4284 | 2075 | 20000.39 | 13.49 | 1482.61 | 2239.08 | 10204.8 | 1.51 | 7 | 7 |
| | Seed drill | 4 | | | | 548.03 | | | | | 19012.25 | 15.66 | 1214.06 | 2370.34 | 18107.3 | 1.95 | 6 | 5 |
| | | 6 | 510.38 | 342.84 | - | 360.79 | 3869 | 7383 | 4284 | 2075 | 18825.01 | 15.88 | 1185.45 | 2382.81 | 19014.0 | 2.01 | 5 | 4 |
| | | 8 | | | | 283.15 | | | | | 18747.37 | 13.69 | 1369.42 | 2208.48 | 11486.7 | 1.61 | 4 | 6 |
| | Comb. unit | 4 | | | | 755.64 | | | | | 18366.64 | 19.20 | 956.60 | 2542.81 | 30455.3 | 2.66 | 3 | 2 |
| | | 6 | - | - | - | 523.38 | 3869 | 7383 | 4284 | 2075 | 18134.38 | 19.36 | 936.69 | 2554.19 | 31314.7 | 2.73 | 2 | 1 |
| | | 8 | | | | 436.66 | | | | | 18047.66 | 17.04 | 1059.13 | 2598.23 | 26226.2 | 2.45 | 1 | 3 |

## 5. REFERENCES

**Abo-EL-Naga, M.H.; Abdel-Galil, M.M. and EL-Ashrey, A.S., 2009.** A proper mechanical system for sowing wheat crop in semi-arid soil. Misr J. Ag. Eng., 26(1): 695- 713.

**Afify, M.K., 2009.** Development of a seed drill feeding device of suit planting in hills. Misr J. Ag. Eng., 26(2): 561-579.

**Ahmed, M.S., 2006.** Evaluation of some land preparation and sowing methods for wheat production in Northern State (Dongola area) - Sudan. M.Sc. Thesis, Dept. of Agric. Eng., Fac. of Agric., Univ. of Khartoum : 44-54.

**Ali, N., 2009**. Resource saving equipment for conservation agriculture leading to higher productivity and profitability. 4th World Congress on Conservation Agric.: 192-194.

**Arifa, W. and Oleh, H., 2018.** Production tests of a seed drill CPH 2000 for direct sowing. INMATEH - Agric. Eng. 56(3): 31-38.

**Dharmendra.; Chandra, S.; Kumar, A. and Kumar, N., 2022.** Effect of tractor forward speed on field performance of zero till seed-cum-fertilizer drill in tilth and un-tilth sandy loam soil. J. of AgriSearch, 9(1).

**EMALR (Egyptian Ministry of Agriculture and Land Reclamation), 2020.** The Central Agency for Public Mobilization and Statistics of Egypt.

**El-Ashmouny, M.S.; Tantawy, A.A.; Salem, M.A. and Hussien, O.M., 2016.** Effect of sowing and weed control methods on yield and its components of some bread wheat cultivars. Minia J. of Agric. Res. & Dev. 36(4): 551-563.

**El-Awad, S.E. and Mohamoud A.M., 2010.** Development and evaluation of a seed drill for bed planting of wheat. Gezira J. of Agric. Sci. 8 (1).

**El-Awady, M.N.; El-Sayed, G.H.; Yehia, I., and Mohamed, A.H.A., 2000**. Evaluation and comparison of mechanical and pneumatic drills for wheat grains, 8th Conf. of Misr Soc. of Agric. 25th Oct. 2000. : 123-136.

**Embaby, A.T., 1985.** A Comparison of the different mechanization systems for cereal crop production. M.Sc. Thesis. Agric. Eng. Dept. Fac. of Agric., Cairo Univ., Egypt.

**FAO, 2017.** Food and agriculture organization of the united nations statistics. [2015-06-12]. http://www.fao.org/faostat/en/#country/59. Available at <https://www.rotoballer.com/ player-news?sport=nfl> (Accessed 17 September 2019).

**Gaidenko, O. and Kernasyuk, Y., 2014.** Combined complexes on sowing, The Ukrainian Farmer, 3: 126.

**Gauchan, D. and Shrestha, S., 2017.** Agricultural and rural mechanization in Nepal: Status, issues and options for future in Mandal, S.M.**;** Biggs, S.D. and Justice, S.E. (ed.) 2017.

Rural mechanization. A driver in agric. change and rural development. Institute for inclusive finance and development (In. M.), Dhaka, Bangladesh (https://cgspace.cgiar.org/bitstream/handle/10568/87968/Gauchan_2017.pdf?sequenc).

**Haque, E.; Bell, R.W.; Kassam, A. and Mia, N.N., 2016.** Versatile seed drill: A 2-wheel tractor-based option for small holders to implement conservation agriculture in Asia and Africa. Environments, 3(1): 1-13.

**Hossain, M.I.; Hossain, I.; Mamun, M.A.; Siddique, N.A.; Rahman, M.M. and Rahman, M.S., 2012.** Two wheel tractor operated strip tillage seeding equipment for dry land farming. Inter. J. of Energy Machinery 5 (1): 35-41.

**Hossain, M.I.; Islam, M.S.; Meisner, C.A.; Bodruzzaman, M. and Hossain, I., 2009.** Minimum tillage one pass seeder for sustaining cropping intensity and profitability in rice-wheat system. Inter. J. Sustain. Agric. Tech. 5(6): 32-37.

**Imbabi, A.T., 2001.** Field evaluation of combination unit for seedbed preparation and planting wheat under Egyptian conditions. Misr J. Ag. Eng. 18(2): 261- 278.

**Javadi, A. and Hajiahmad, A., 2006.** Effect of a new combined implement for reducing secondary tillage operation. Int. J. Agri. Biol., 8(6): 724-727.

**Jha, R.N.; Ansari, M.S.; Thakur, M. and Mahato, R.A., 2019**. Production evaluation of wheat through the use of different cultivation practices using different machineries at agricultural machinery testing and research centre, Sarlahi, Nepal. Int. J. Curr. Microbiol. App. Sci., 8(11): 1483-1503.

**Jithender, B.; Sunitha, D.V.; Upender, K. and Rami. R.K.V., 2017.** Performance study of tractor operated rotary plough in two different soils. Int. J. Curr. Microbial. App. Sci., 6(10): 871-878.

**Kepner, R.A.; Bainer, R. and Barger, E.L., 1982.** Principles of farm machinery. 3$^{rd}$ edit. AVI Publishing Company, INC. Westport, Connecticut, USA: 209-236.

**Khalequzzaman, K.M. and Karim, M.A., 2007.** Study of agricultural mechanization and its impact on rural environment. J. of Innovation and Development Strategy, 1: 37-40.

**Khurshid, F.F. and Sedeeq, A.M.A., 2019.** Power requirement for sowing patterns on two fallow lands under wheat production. Applied ecology and environ. Res., 17(6): 12731-12751.

**Klute, A. (ed.), 1986.** Methods of Soil Analysis. Part-I: Physical and Mineralogical Methods. (2$^{nd}$). American Society of Agronomy, Madison, Wisconsin, U.S.A.

**Mohamed, D.R., 2016.** Comprehensive evaluation of different seeded preparation systems for sugar beet production. M.Sc. Thesis. Agric. Eng. Dept. Fac. of Agric., Cairo Univ., Egypt.

**Morad, M.M.; Sief EL–Yazal, M.N. and Afify, M.K., 2001.** Development of combination unit for secondary tillage and seeding wheat crop. Misr J. Ag. Eng., 18(4): 202-218.

**Omar, O.A. and Abdel-Hamid, S.G., 2021.** Effect of some seed bed preparation systems on wheat yield under raised bed-mechanical drilling method. J. of Soil Sci. and Agric. Eng., Mansoura Univ., 12 (9): 621-625.

**Page, A.I.; Miller R.H. and Keeney, D.R. (Eds), 1982**. "Methods of Soil Analysis" part 2: Chemical and Microbiological Properties. 2nd ed. Amer. Soc. of Agron., Madison, Wisconsin, U.S.A.

**Quasim, M.; Shrivastava, A.K.; Rautaray, S.K. and Gautam A.K., 2019.** Comparative evaluation of zero-till-slit seed drill and combined tillage and seeding equipment in rice. Int. J. of Current Microbiology App. Sci., 8(6): 132-149.

**Rahman M.S.; Monayem M.M. and Hossain, S., 2011.** Impact of farm mechanization on labour use for wheat cultivation in northern Bangladesh. J. of Animal and Plant Sci., 21(3): 589-594.

**Sarauskis, E.; Buragiene, S.; Romaneckas, K.; Sakalauskas, A.; Jasinskas, A.; Vaiciukevicius, E. and Karayel, D., 2012.** Working time, fuel consumption and economic analysis of different tillage and sowing systems in Lithuania. In Proceedings of 11th Inter. Scientific Conf. on Eng. for Rural Development. Latvia Univ. of Agric., Jelgava, 11, p. 5.

**Sarhan, A.M.M.; Al-katary, H.S. and El-Awady, M.N., 2010.** A study on Agricultural Tractors Steering Mechanism. The 17th Annual Conference of the Misr J. of the Agric. Eng., 27(4): 981-1002.

**Snedecor, G.W. and Cockran, W.G., 1980.** "Statistical Methods" (7m ed.). Iowa State University, Iowa, U.S.A. soil physical conditions: a review. Nut. Cycl. Agroecosyst., 51: 123-137.

**Tao, Z.Q.; Wang, D.M.; Ma, S.K.; Yang, Y.S.; Zhao, G.C. and Chang, X.H., 2018.** Light interception and radiation use efficiency response to tridimensional uniform sowing in winter wheat. J. of Integrative Agric., 17: 566–578.

**USDA (United States Department of Agriculture), National Agricultural Statistics Service [NASS], 2017,** Cropscape—Cropland Data Layer: U.S. Department of Agriculture, National Agricultural Statistics Service, accessed March 7, 2017, at https://nassgeodata.gmu.edu/CropScape/**.**

**Valainis, O.; Rucins, A. and Vilde, A., 2014.** Technological operational assessment of one pass combined agricultural machinery for seedbed preparation and seeding. Proceedings on 11th Inter. Scientific Conf. on Eng. for Rural Develop.. Latvia 29-30 May: 37-43.

**Verma, A. and Guru, P.K., 2015.** Development and evaluation of cultivator cum seed drill. Eco. Env. and Cons. 21(3): 1359-1364.

**Younis, S.M., 1997.** Machinery Management. Textbook. Agric. Eng. Depart. Fac. of Agric., Cairo Univ., (In Arabic): 83-97.

# تقييم أداء وحدة مجمعة لزراعة القمح في الحيازات الصغيرة

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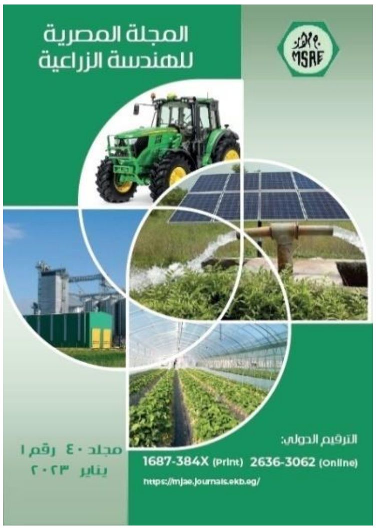
**الملخص العربي**

لأختيار طريقة مناسبة لزراعة حبوب القمح. تمت الدراسة بهدف تقييم أداء آلة الوحدة المجمعة لزراعة القمح في الحيازات الصغيرة مقارنة بطريقة السطارة والزراعة التقليدية. أجريت التجربة بمزرعة كلية الزراعة جامعة الفيوم، قُسمت مساحة التجربة إلى ثلاثة شرائح رئيسية لتطبيق معاملات طرق الزراعة (الوحدة المجمعة، السطارة، الطريقة التقليدية). قُسمت كل شريحة رئيسية إلى ثلاثة شرائح تحت رئيسية لتطبيق السرعات الأمامية للجرار (٤ و ٦ و ٨ كم/ساعة). أُستخدم تصميم القطع المنشقة مرة واحدة بين المعاملات. تمت زراعة بذور القمح (صنف مصر ١) خلال موسمين متتاليين (٢٠١٩/٢٠٢٠ ، ٢٠٢٠/٢٠٢١). تم تقدير السعة الحقلية ومتطلبات الطاقة وإنتاجية القمح والعائد الاقتصادي. تشير النتائج الى أن أعلى قيم للكفاءة الحقلية كانت ٧٣,٧٤ و ٨١,٧٦٪ والطاقة المطلوبة كانت ٦١,٨٤ و ٣٢,٦٣ كيلو وات ساعة/فدان وسُجلت هذه القيم مع السرعة ٤ كم/ساعة عند الزراعة بالسطارة والوحدة المجمعة على التوالي. وجد أن أعلى زيادة بقيم محصول القمح كانت ٣٣,٣٢٪ للحبوب و ١٥,٦٦٪ للقش عند استخدام السطارة، وكانت ٧٣,٧٠٪ للحبوب و ٣٠,٥٤٪ للقش عند استخدام الوحدة المجمعة مع السرعة ٦ كم/ساعة مقارنة بالزراعة التقليدية. أتضح أن الزراعة بالوحدة المجمعة عند السرعة ٨ كم/ساعة أعطت أقل قيم للتكلفة الكلية للمحصول (١٦٣٥٢,٧٧ جنيها مصريا/هكتار). أيضا وجد أن استخدام آلة الوحدة المجمعة عند السرعة ٦ كم/ساعة أعطت أعلى صافي ربح اقتصادي من محصول الحبوب والقش (٣١٩٥٧,٠ و ٣١٣١٤,٧ جنيه للهكتار لكل من الموسم الأول والموسم الثاني على التوالي). يمكن التوصية باستخدام الوحدة المجمعة لزراعة القمح لعمل حد أدنى من الحرث مع عدم زيادة السرعة الامامية للجرار عن ٦ كم/ساعة للحصول على أفضل قيم للكفاءة الحقلية والطاقة المطلوبة والعائد الاقتصادي من محصول القمح.

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الوحدة المجمعة؛ السطارة؛ الطريقة التقليدية؛ معدل الأداء؛ الكفاءة الحقلية؛ الطاقة المطلوبة؛ الحيازات الصغيرة؛ العائد الاقتصادي؛ القمح.