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Effect of Field Size on Mechanical Wheat Seeder Performance in Reclaimed Lands of Egypt

Mona M. A. HASSANN[1], Islam M.M. KHATER[2], Baran YAŞAR[3]
[1]Agric. Engineering Dept., Zagazig University, Egypt.
[2]Soil and Water Conservation Dept., Desert Research Center, Cairo, Egypt.
[3]Cukurova Uni., Fac. of Agriculture, Dept. of Agricultural Economics,Turkey.
islam_hankhater@yahoo.com

Abstract: This research was carried out to study the effect of different field size areas (0.41, 2.09, 4.18, and 6.27 ha) on the field capacity, field efficiency, energy requirements, productivity and operation costs for wheat production in reclaimed areas. Two seeding techniques were compared: a mechanical seeder and broadcasting machine. Wheat seeding was performed after primary chiseling followed by disk harrowing for seedbed preparation. The results obtained allowed to conclude the following:seed planter allowed a saving in wheat seeds of 26 % compared with the broadcasting technique and field capacity decreased from 0.28 ha/hour for broadcasting machine to 0.26 ha/hour for seeder under large size area. Energy requirements were 21.00 and 21.65 kW h ha^{-1} in size area of 4.18 ha for seeder and broadcasting techniques, respectively. Averaged over seeder type, grain yield increased by closely 2 Mg/ha from an area of 0.41 ha to a larger area of 6.27 ha and averaged over area sizes, the utilization of seeder allowed a wheat yield increase of 13 % as compared with broadcasting machine. When shifting from broadcasting to drilling, the wheat productivity from the largest sized area increased from 17.32 to 20.07 Mg/ha and the total cost decreased from 95.91 to 52.51 dollars/ha.
Key words: Wheat, energy, seeder, reclamation, fuel consumption

INTRODUCTION

Wheat is considered one of the most important crops; it takes a great part in the food policy. It is one of the strategic crops on both the new reclaimed areas and also in Delta valley (Aboul Enien et al., 2000).

In Egypt, FAO (2005) reported that the wheat planted area is 1.05 million ha, with an average yield of 1147 kg/ha and net economical return of 427 LE/ha. Wheat production increased from 2 million Mg in 1982 to 6.8 million Mg in 2003.

In fact, for Egypt, improving wheat production through increasing the productivity per unit area together with expanding the cultivated area in newly reclaimed lands is the most important national target. However, the lack in agricultural labor in the reclaimed areas lead to increase in production cost, therefore mechanization represents an important factor to reduce the costs and increase the productivity.

Amin (1983) pointed out that the seed drill machine lead to scattering for the small seeds, about 97% of the wheat seeds replaced in band with 5 cm width, while in broad bean seeds, about 95.8% replaced in band with 6 cm around the center of rows. Abo El-Ees (1985) showed that the method of mechanical drilling for seeds affect mainly the seeding depth, seed placement uniformity and lead to yield increase as compared with manual planting.

Kraus (1984) found that the four wheel tractor 50kW had the highest capacity, which was from 1.0 to 2.4 ha/day in one shift under favourable conditions, nearly 25 times the human capacity. The effect of area on the mechanical practices of cotton production was discussed by Abd El-Maksoud et al. (1994). They mentioned that energy requirement, for different implements, was affected by the tractor size and plot area. The energy requirements and fuel consumption decreased with increasing plot area ranging from 89.5 to 29.8 kW. The energy requirements and fuel consumption increase with increasing size of tractors. In a chisel based tillage system, Abdo (1996) reported that mechanical planting increased wheat productivity compared with manual planting. The seeding rate was

138.62 and 167.3 kg/ha for mechanical and manual planting, respectively.

Wuest et al. (1999) indicated that, independently of seeding technique, seed–soil contact had very little effect on time to germination. Lan et al. (1999) determined that uniform seed spaces are important for crops such as sugar beet, because seed spacing uniformity is a significant factor affecting production yield and cost. Morrison et al. (2005) summarized that systematic determination of planting machine requirements starts with the evaluation of management conditions for each individual farming operation. The machinery requirements can be established and matched with available machines and add-on components for the selection or modification of appropriate planters and drills.

Jonathan et al. (1988) stated that no-till and ridge plant tillage system result in 84 and 54% drawbar energy saving respectively. The reduced tillage regime used 62% less drawbar energy than the conventional system commonly practiced in the area. Attention must be placed on matching the implement to tractor size, so fewer operations occur at part load.

Micheal and Ojha (1966) showed that broadcasting is a technique of seed scattering on the field's surface. Seeds are then covered by manipulating the soil and planking it to be covered by hand tools. They pointed out that drilling means dropping the seeds in the furrow through seed tubes.

In the arid and semi-arid conditions of West Nubaria (Egypt), farmers are planting wheat before the rainy season in order to maximize the use of growing season rainfall. The seed broadcasting technique allows more time than the mechanical drilling which requires seedbed preparation before seeding. The drilling technique consumed much time and need more soil manipulation. However, this later technique may provide higher wheat productivity and savings if used on larger fields.

The main objective of this research is to study the effect of different field plot areas on wheat planting machinery performance in terms of productivity, field efficiency, energy and cost in a reclaimed area of Egypt.

MATERIAL and METHODS

II-1- Experimental site and soil

The experiments were carried out on a sandy loam soil located in West Nubaria in International Company of Land Reclamation (private sector). Main soil properties are shown in table (1). The soil is high in sand content and very low in organic matter.

In the location of the research, North Western Coast Zone, the climate plays an important role. Along the 50 km from the coast of Mediterranean sea, the average long-term annual rainfall is 140mm.

II-2- Treatment description

The cultivation of wheat started in the first of November and the harvesting started in May every year. The local varieties used named Skha 8 and Sids 1, with seeding rate ranging from 95 to 120 kg/ha. The most popular way of planting is the manual method especially in Delta Valley, but in the new reclaimed areas, the mechanical planting by seeders was the most common one, the row distance ranged from 12-14 cm with seeding depth of 4-5 cm.

Tillage system consisted of chisel plow followed by disk harrow for seedbed preparation. Two seeding techniques are compared in this experiment: mechanical planting and broadcasting. Seeding is carried out after seedbed preparation. The details on the two planting machines are as follows:

Table 1: Selected soil physical and chemical properties

Soil depth (cm)	Particle size distribution			Textural class	pH	Electrical Conductivity (dSm^{-1})	Calcium carbonate (%)	Organic matter (%)
	Sand %	Silt %	Clay %					
0-30	81.4	2.5	16.1	Sandy Loam	8.37	1.62	4.24	0.55

- Mounted seed drill, the model is Saxon 427 (made in Germany) with 25 cm in-row spacing and working width of 2.5 m. The mass of the machine is 800 kg. This machine can plant the wheat seeds in uniform rows on stable depths, it can open furrows to drop the seeds;
- Mounted dung scattering machine Ontar (made in Turkey). This machine contains 450 Litters as volume with variable working width (13.75 m), and the source of power is from the tractor used (540 rpm) with throwing system consisting of 4 blades to spread the seeds. This machine was used basically to spread both manure and chemical fertilizers, but can also be used to spread small seeds like barley, wheat, forage and alfalfa especially in sloping lands, but the distribution uniformity of this machine was less than the mechanical seeders.

II-3- Field measurements

They consisted upon the following parameters:

II-3-1. Engineering parameters (Effective Field capacity and efficiency of the machines used, power and energy consumed) for different area sizes.

Effective field capacity was estimated using formula developed by Elmo (1981):

$C = S.\ W.\ \zeta_f / 4200$ (Hectar h^{-1})

Where:
C = Effective field capacity (Hectar h^{-1})
S = Ground speed (km/h)
W = Machine width (m)
ζ_f = Field efficiency (%)

$EP = (FC\ .\ 1/\ 3600)\ .\ \rho_f\ .\ LCV\ .\ 427\ .\ \eta_{th}\ .\ \eta_m\ .\ 1/75\ .\ 1/1.36$ (kW).

Where:
FC = the fuel consumption, L/h
ρ_f = Density of fuel, kg/L (for solar fuel = 0.85 kg/L)
LCV = Lower calorific value of fuel, kcal/kg, (average LCV of solar fuel is 10000 kcal/kg)
427 = Thermo-mechanical equivalent, kg.m/kcal
η_{th} = Thermal efficiency of the engine, (considered to be about 40 % for diesel engine)
η_m = Mechanical efficiency of the engine, (considered to be about 80 % for diesel engine)

EP = 3.16 FC

Energy requirement was calculated using the following equation:

Energy requirements (kW h ha^{-1}) =

$$\frac{\text{Engine power (kW)}}{\text{Effective field capacity } (ha/\text{h})}$$

Engine power (EP) was determined using formula by Embaby (1985).

II-3-2- Wheat productivity or grain yield

For each planting system, grain yield is determined after harvesting wheat from each field size and given in kg ha^{-1}.

II-3-3- Operation costs under the 2 planting systems

Costs in LE per ha for seedbed preparation were calculated for each operation. LE is an abbreviation of Egyptian pound (1$ = 5.30 LE).

RESULTS and DISCUSSION

III-1- Field capacity and efficiency:

Figures 1 and 2 illustrate the effect of field area on both field capacity and efficiency. The results indicated that increasing field area tend to increase field capacity for tillage and seeding operations. The highest values of field capacity for chiseling, harrowing, broadcasting and seeding were 0.37, 0.74, 0.38 and 0.36 ha h^{-1} respectively at field area of 6.27 ha. However, the lowest field capacity was 0.27, 0.54, 0.28 and 0.26 ha h^{-1} obtained at field area of 0.41 ha.

Data showed also that increasing the field area lead to increase in field efficiency. The highest values of field efficiency for chiseling, harrowing, broadcasting and seeding were 89.5, 96.87, 97.2 and 98.6 (%) respectively at field area of 6.27 ha. However, the lowest field efficiency was 65.2, 70.57, 76 and 77 (%) obtained at field area of 0.41 ha.

III-2- Energy requirements

Figure 3 represents the effect of field area on energy requirements. The results obtained revealed that increasing field area decrease the energy required, however the highest values of energy requirements for chiseling, harrowing, broadcasting and seeding were 48.23, 32.36, 21.00 and 21.65 kW h ha^{-1}, respectively, at field area of 0.41 ha., while, the lowest values of energy requirement were 27.38, 13.57, 10.75 and 11.08 kW h ha^{-1} respectively, at field area of 6.27 hectares. The data pointed out that in the largest field area; the return numbers of the

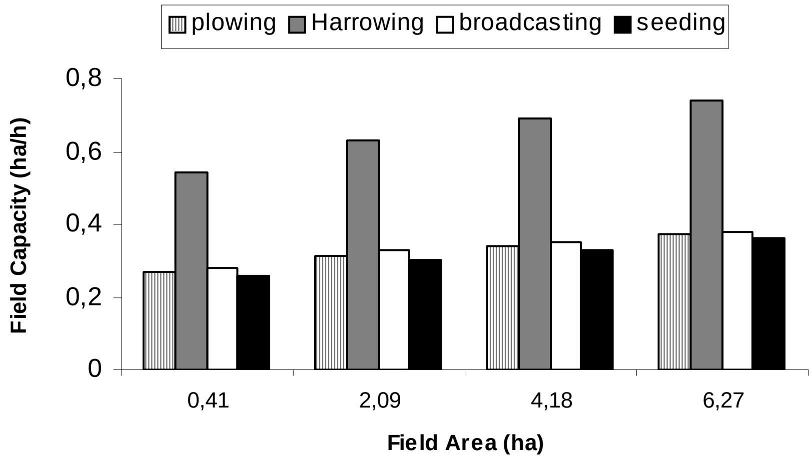

Figure 1: Effect of field area size on effective field capacity of wheat cultivation and seeding.

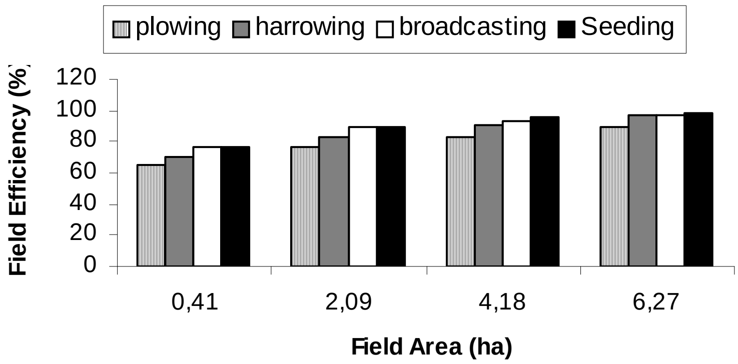

Figure 2: Effect of field area size on field efficiency of wheat cultivation and seeding.

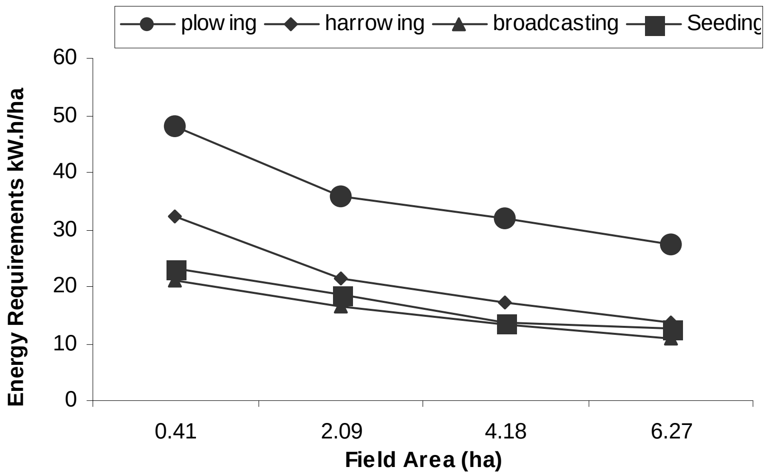

Figure 3: Effect of field area on energy requirements.

machinery decreased which decrease the energy consumption. For each field operation, a regression equation was developed to show the relation between the field area (ha) and energy requirement (kW h ha^{-1}).

Chisel plowing : $y = 20.091x^{-0.3972}$ $R^2 = 0.993$

Harrowing : $y = 13.682x^{-0.6157}$ $R^2 = 0.9963$

Broadcasting : $y = 9.0875x^{-0.4732}$ $R^2 = 0.9717$

Seeding : $y = 9.9187x^{-0.4627}$ $R^2 = 0.9636$

Where

X = Field area (ha)

Y = Energy requirement kW h ha^{-1}

III-3- Wheat grain yield

It is important to notice that mechanical seed planter allowed a saving in wheat seeds of 26 % compared with the broadcasting technique. Figure 4 shows the effect of field area size on wheat grain yield. It is clear from the figure that wheat yield was higher as field area increases and that mechanical seeder permitted higher yields than broadcasting. Averaged over area sizes, the usage of mechanical seeder increased wheat yield by 13 % as compared with broadcasting machine.

The results indicated that increasing field area increases wheat yield. The highest values of yield for broadcasting and seeding were 8.91 and 11.04 Mg/ha respectively at field area of 6.27 ha, while the lowest yields were 5.90 and 7.64 Mg/ha obtained at field area of 0.41 ha. The same data showed that the positive effect of large field area on wheat yield can be due to the increasing of machine efficiency and net cultivated area especially with the large areas.

In other terms, averaged over seeder type, grain yield increased by closely 2 Mg/ha from an area of 0.41 ha to a larger area of 6.27 ha. This can also be due soil manipulation by tillage which may favor compaction at the surface in small field areas

III-4- Operation costs

The results in figure 5 indicated that increasing field area decreased the operation costs. It shows that the lowest values of plowing, harrowing, broadcasting and seeding costs were 478, 286.8, 246.1 and 152.9 L.E ha^{-1}, respectively, are associated with field area size of 6.27 ha. However, the highest operation costs were 693.1, 501.9, 454.1 and 296.3 L.E./ha obtained at field area of 0.41 ha. This is due to the decreasing number of field turns, the reduced fuel consumption and the lower seed quantities with net cultivated area especially with the large areas.

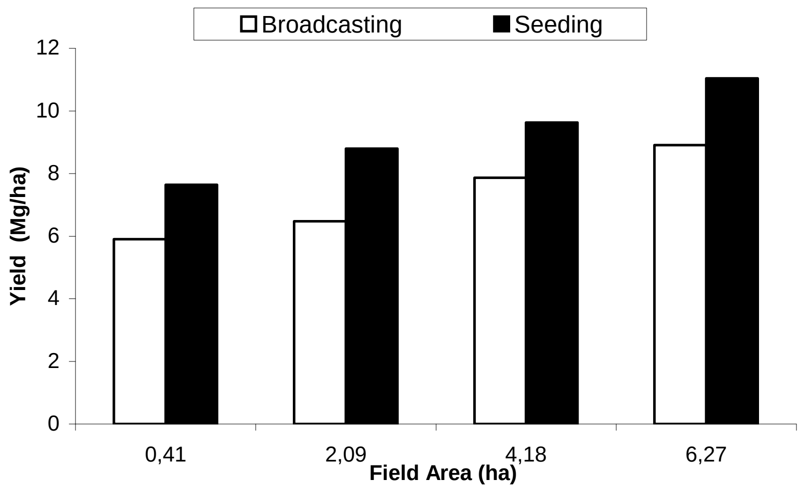

Figure 4: Effect of field area on wheat grain yield for two seeding techniques.

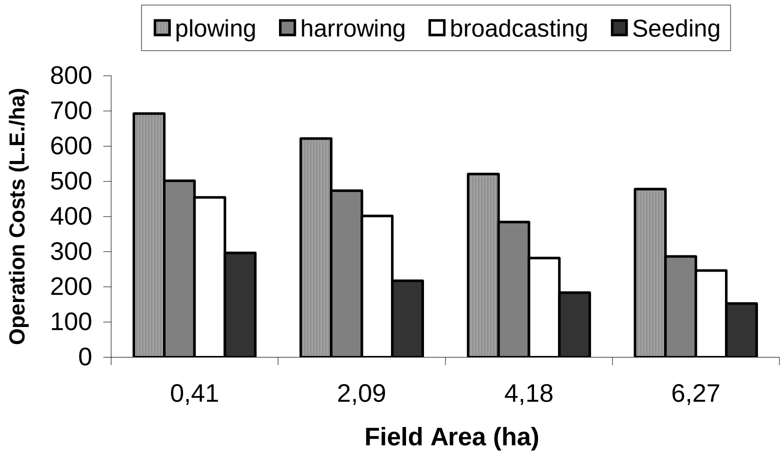

Figure 5: Effect of field area on cost of each tillage and seeding operation.

CONCLUSION

The main conclusions from this study can be summarized in the following:

1. The mechanical planting using broadcasting machine and seeder showed that there were no obvious differences in both field capacity and efficiency under the same cultivated area, while a notable difference can be found with increasing the cultivated area.
2. Increasing the cultivated area lead to remarkable decrease in energy requirements in the following order: plowing > harrowing > seeding > broadcasting.
3. Increasing field area, grain yield increased with the seeder permitting higher values than broadcasting.
4. The use of seeder gave the lowest values of operation costs as compared with broadcasting machine and increasing the field area decreased further the operation costs. The order of operation costs was as follows: plowing > harrowing > broadcasting >seeding.

From the obtained results, the following recommendations can be formulated:

- More available field area gave higher field capacity and efficiency and higher yields with less energy requirement and operation cost.

The mechanical planting using seeder is better than planting by broadcasting machine.

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