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Technical Evaluation Of A New Combined Implement For Seedbed Preparation

Nasr, G. E[1]., Tayel, M. Y.[2], Abdelhay, Y.B.[1]
Sabreen, Kh. Pibars[2], Dina, S. Salama[2]

1. Agricultural Engineering Department, Faculty of Agriculture, Cairo University, Egypt.
2. Water Relation and Field Irrigation Department, National Research Centre, Egypt

Abstract : Field experiments were carried out on clay loam soil in split-split plots design at the experimental center, Faculty of Agricultural, Cairo University, Giza Governorate, Egypt in cooperation with National Research Center, Egypt. The aim of the investigation was to evaluate a new combined implement for seedbed preparation, concerning fuel consumption (F_{Con}), tractor wheel slip(S%), Actual Field Capacity (AFC), and Brake horsepower requirement (BHP) under the following circumstances: (1)Three different soil moisture content (SMC) at θ_1, θ_2, θ_3 (23, 18.2; 9.5%V/V), (2) Three different working forward speed (FS); S_1, S_2, S_3 (3.85, 4.69; 5.30 Kmh-1) and (3) Two plowing depth (PD), D_1, D_2 (15;25 cm). Data obtained were subject to statistical analysis to find the effects of the treatments and their interaction a ction on evaluation criteria. The differences in criteria among treatments were significant at the 5% level. The most important results was increasing of AFC of machine compared to the traditional method of preparing soil, the highest value of it was 1.98 fed/h compared to the traditional method 1.23 fed/h. Combined machine had lowest wheel slip percentage under different operating conditions, the minimum value of S was 5.39% . The results showed an decreasing in fuel consumption which the minimum value was 4.86l/h.
Keywords: Combined impelement, Seedbed preparation, Clay loam, Technical evaluation.

Introduction

Tillage is one of the oldest agricultural practices. Its history dates back many millennia when humans changed from hunting and gathering to a more sedentary and settled agriculture, mostly in the Tigris, Euphrates, Nile, Yangtze and Indus river valleys[1]. Ancient people used the tools such as digging stick and plow to place seeds in the soil in order to protect them against birds and rodents and vagaries of climate [2]. The main purposes of tillage in agricultural production are to: soften the soil and prepare seedbed, control weeds for better crop growth, release nutrient through enhanced mineralization and oxidation, temporarily reduce the soil compaction, control crop diseases/insects and so on [3]. The objective of mechanics tillage tools is to provide a method for describing the application of forces to the soil and its reaction to the forces. An accurate mechanic would provide a method by which the effects could be predicted and controlled by the design of a tillage tool or by the use of a sequence of tillage tools[4].

Based on operations that can be carried out, the combined agricultural machineries can be divided into five groups: Soil preparation: plowing and compacting, leveling and loosening, and cultivating and loosening. Soil preparation and fertilizing: cultivating and fertilizing. Soil preparation, fertilizing and seeding: plowing fertilizing and seeding, tilling fertilizing and seeding, cultivating fertilizing and seeding and direct seeding. Soil preparation and seeding: plowing and seeding, tilling and seeding, cultivating and seeding, and direct seeding . Fertilizing and seeding: fertilizing and seeding. There are several combinations in almost each of the groups, e.g., in the first group there is agricultural combined machinery that is doing only the soil preparation: plowing and compacting, leveling and loosening, cultivating and loosening[5]. [6]mentioned that using combined equipment and reducing the number of passes is getting popular due to its effect on time, efficiency and costs. Design and development of combined machine were considered in both primary and secondary tillage operations from about hundred years ago. The combinations of the chisel plow + rotavator, disc harrow + leveler or chisel plow +roller are the examples[7]. [8] developed a combined machine consisting of disk plow and chisel plow and reported that this could be a suitable substitute of moldboard plow for soil conditions in Iran.

The main objective of this study was to evaluate a new combined impelement for seedbed preparation technicaly under different operating condutions.

Materials and methods

1. Experiment layout

The experiments were carried out at Experimental center, Faculty of agriculture, Cairo University in cooperation with the National Research Center in clay loam soil (Clay 51.20%, Silt 38.58 %, Sand 10.22 %). The experiment was designed in split-split plot with treatment; three different soil moisture content (SMC): θ_1, θ_2, θ_3 (23, 18.2 and 9.5% V/V), three different working forward speed (FS): S_1, S_2, S_3 (3.85, 4.69 and 5.30 Kmh^{-1}) , and two plowing depth (PD): D_1, D_2 (15;25 cm).

2. Combined implement

The combined implement (Fig 1.) containe three main parts, seven tines chesil plow as primary tillage, packer roller as secondry tillage tool and finally tow consecutive blades. Combined specification showed in (Table. 1). The combined implement was compareded with traditional method for prepearing the soil and no-tillage method. Traditional method conducting under 18% soil moisture content and 25cm plowing depth.

Figuer 1. Combined implement

3. Measurements

a. Field capacity

The actual field capacity AFC (fed/h) was calculated as follows [9]:

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

Where:

T_t = actual time consumed to seedbed preparation for one fadden,(h/Fed.)

b. Fuel consumption

Estimation of the fuel consumption ($F_{con.}$) for seedbed preparation was carried by measuring the decrease in fuel level in fuel tank after a certain period of time.

c. Wheel slip percentage

Wheel slip percentage (S%) was determined by using the following equation (Srivstava 1990) [10] :

$$S\% = \frac{L_1 - L_2}{L_1} \times 100$$

Where
L_1 = advance per 10 wheel revolution with no pull, (m).
L_2 = advance per 10 wheel revolution with pull, (m).

d. Brake horsepower requirement

To estimate brake horsepower requirement during operation , the decreased in fuel level was measured after each treatment . By using the following formula [11] getting brake horsepower requirement:

$$BHP = [\ F_{con} \times (\frac{1}{3600}) \times \rho f \times L.C.V \times 427 \times \eta_{th} \times \eta_m \times \frac{1}{75}\ ]$$

Where:

BHP = brake horsepower requirement, (HP).
F_{con} = Fuel consumption, (lit./h).
ρ_f = fuel density, (0.85 kg/l).
L.C.V = lower calorific value of fuel, (10000 k.cal/kg).
427 = thermo-mechanical equivalent, (kg.m/k.cal.).
η_{th} = thermal efficiency of the engine, (40% for diesel).
η_m = mechanical efficiency of the engine, (80% for diesel).

Table (1): The combined implement specifications

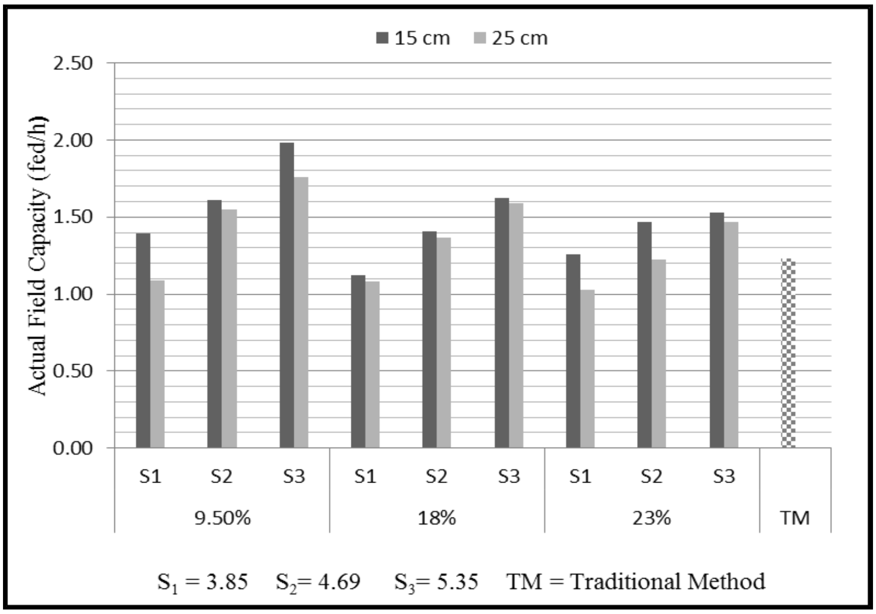
Main Part	**Specifications**
Chisel Plow	
- Working width	170 cm
- No. of blade	7 tines
- Blades arrangement	3 front, 4 rear
Packer roller	
- Working width	180 cm
- No. of blade	16 tines
- Types of blades	Circular Toothed tines
Riddger	
- Working width	120
- No. of blades	2

Results and discussion

1. Actual Field Capacity (AFC)

Figure (2) illustrated the AFC under the experiment different operating condition. It is clear that by increasing of working forward speed the **AFC** was increased at the same soil moisture content and decreased by increasing of plowing depth. Results agreed with[12]. whose results said that by increasing the plowing depth the

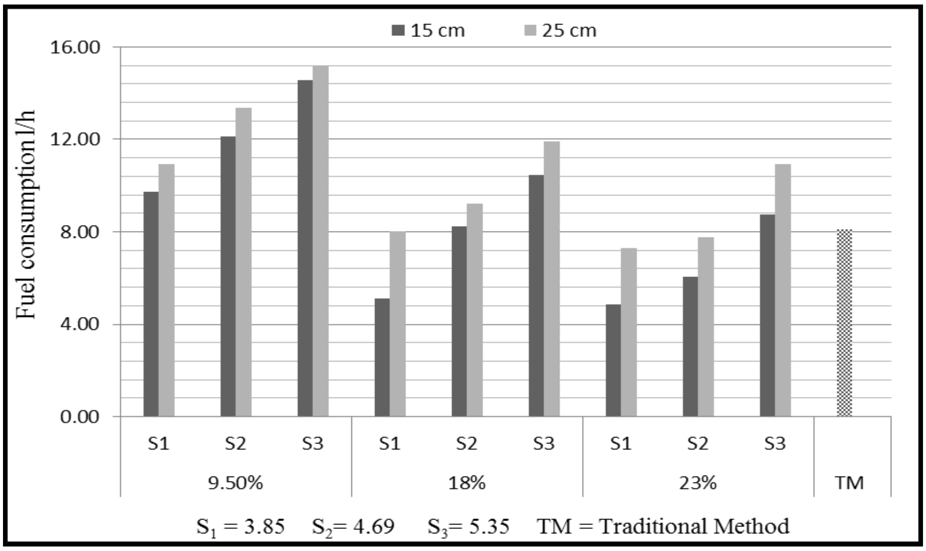
AFC was decreased while it increased by increasing the forward speed. [13] stated that the increasing of plowing depth from10 to 20 cm caused in decreasing the field capacity. This trend may be due to that increasing of soil moisture content resulting in increasing total time losses. The maximum value of AFC was represented in treatment ($\theta_3 \times S_3 \times D_1$) and the minimum one was at treatment ($\theta_1 \times S_1 \times D_2$). According to the main effects of the operating conditions, treatments can be arranged in the following descending order: $\theta_3 > \theta_2 > \theta_1$, $S_3 > S_2 > S_1$, and $D_2 > D_1$. The interaction between the operating conditions showed that there were significant differences between treatmens at 5% level. Compared to Seedbed preparation traditional method for onion yield, the new combined implement achieved highly AFC values in general. The AFC value of traditional method was 1.23 fed/h while the maximum value of the combined machine was 1.62 fed/h.



Figuer 2. Effect of soil moisture content, working forward speed and plowing depth on Actual Field Capacity

2. Fuel Consumption (Fcon)

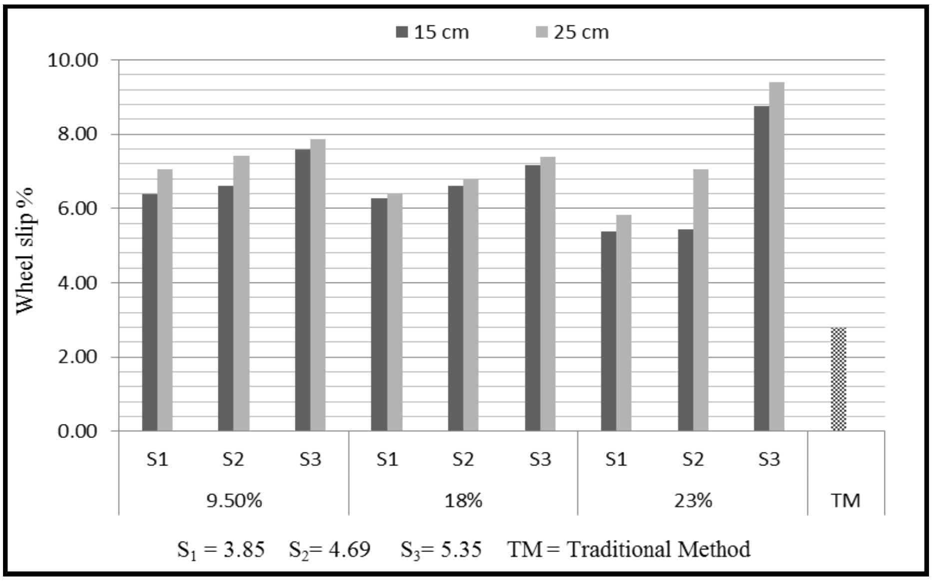
It was evident from Figuer (3) that decreasing of soil moisture content, plowing depth, and working forward speed caused in increasing of F_{con}. This results agreed with [14] who found that increase in ploughing depth and ploughing speed significantly increases tractor fuel consumption This trend may be due to increasing of brake horsepower requirement by increasing soil moisture content and both working forward speed and plowing depth. The maximum value of F_{con} was represented in treatment ($\theta_3 \times S_3 \times D_2$) and the minimum one was in treatment ($\theta_1 \times S_1 \times D_1$). The maximum value was 15.18 l/h and the minimum one was 4.86 l /h. According to the main effects of the operating conditions, treatments can be arranged in the following descending order: $\theta_3 > \theta_2 > \theta_1$, $S_3 > S_2 > S_1$, and $D_2 > D_1$. The interaction between the operating conditions showed that there were significant differences between treatmens at 5% level.



Figuer 3. Effect of soil moisture content, working forward speed and plowing depth on Fuel consumption

3. Wheel Slip percentage (S%)

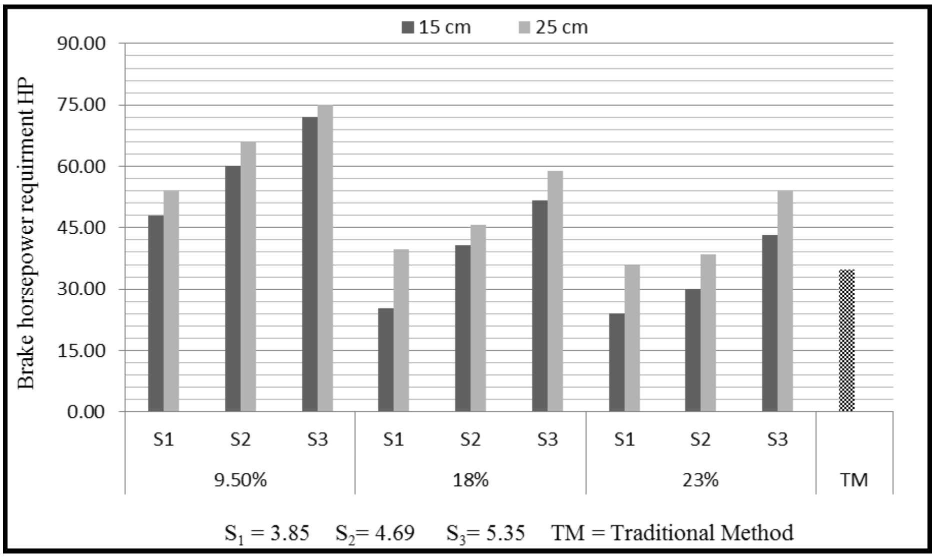
Figure (4) showed the effects of soil moisture content, plowing depth and working forward speed on (S%). It is clear that by increasing of soil moisture content, working forward speed, and plowing depth, (S%) was increased. The maximum value represented in ($\theta_1 \times S_3 \times D_2$) and the minimum one in ($\theta_1 \times S_1 \times D_1$) and they equal 9.41 % and 5.39 % respectively. This trend may be due to soil moisture content which its increasing cased in decreasing of soil hardness. First the resistance of soil decreases and then because soil particle sticks to each other and to the tools, it will increase. By increasing the soil moisture content and because of increasing the Adhesion force between the soil and tillage system, the rolling resistance of tractor wheels increased. [15] showed that by increasing the plowing depth, cohesion and adhesion of soil increased. By increasing the cohesion of soil the rolling resistance of tractor increased and it decreased the tractive efficiency of tractor. According to the main effects of the operating conditions, treatments can be arranged in the following descending order: ($\theta_3 > \theta_1 > \theta_2$), ($S_3 > S_2 > S_1$), and($D_2 > D_1$). The interaction results indicated that there were non-significant differences between treatments on wheel slip values.



Figuer 4. Effect of soil moisture content, working forward speed and plowing depth on Wheel Slip percentage.

4. Brake horsepower requirement (BHP)

Figure (5) showed BHP under the different operating conditions. It is clear that decreasing soil moisture content, and increasing both working forward speed and plowing depth, the BHP was increased. This trend may be due to the effect of soil moisture content increasing on rolling resistance, wheel slip , and fuel consumption. The highly soil moisture content level cased in highly fuel consumption. By increasing the plowing depth, more power is need to cut and transfer soil [16]. This results agree with [17] who said that increase inworking forward speed, ploughing depth, and soil moisture content increases both fuel consumption and wheel slip. The maximum value and minimum value were represented in treatments ($\theta_3 \times S_3 \times D_2$) and ($\theta_1 \times S_1 \times D_1$) respectively. The interaction results indicated that there were significant differences between treatments on BHP values at the 5% level. Treatment ($\theta_3 \times S_3 \times D_2$) was the highly significant value while treatment ($\theta_1 \times S_1 \times D_1$) was the lowest.



Figuer 5. Effect of soil moisture content, working forward speed and plowing depth on Brake horsepower requirement

Conclusion

The main objective of the study on hand was to evaluate a new combined implement for seedbed preparation under different condition of soil moisture content, plowing depth and forward speed. Based on the results obtained in this study, the following conclusions can be drawn:

1. The new combined implement achieved highly AFC values in general comparded with the traditional method of seedbed preparation.
2. The maximum value of F_{con} was represented in treatment ($\theta_3 \times S_3 \times D_2$) and the minimum one was in treatment ($\theta_1 \times S_1 \times D_1$). The maximum value was 15.18 l/h and the minimum one was 4.86 l /h.
3. The maximum value of (S%) represented in ($\theta_1 \times S_3 \times D_2$) and the minimum one in ($\theta_1 \times S_1 \times D_1$) and they equal 9.41 % and 5.39 % respectively.
4. The maximum value and minimum value of BHP were represented in treatments ($\theta_3 \times S_3 \times D_2$) and ($\theta_1 \times S_1 \times D_1$) respectively

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