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Kareem & Jassim

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A STUDY OF THE EFFECT OF AN EIGHT-PURPOSE COMPOUND MACHINE ON SOME PHYSICAL SOIL PROPERTIES

***Aslam M. H. Kareem*[1] , *Abdul Razzaq A. L. Jassim*[2]**

[1]College of Agricultural Engineering Sciences, University of Baghdad, Baghdad, Iraq. **Aslam.kareem2103m@uobaghdad.edu.iq**

[2]Professor PhD. College of Agricultural Engineering Sciences, University of Baghdad, Baghdad, Iraq, **bdulrazzak.Jasim@coagri.uobaghdad.edu.iq**

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ABSTRACT

A field experiment was conducted to evaluate the effect of a locally developed and assembled eight-purpose compound equipment on some physical soil properties in a silty clay loam soil in one of the fields of the College of Agricultural Engineering Sciences/University of Baghdad/Al-Jadriyah for the spring growing season of 2023. The experiment used, the MF-650 Tractor. The study included two factors: the first factor had three seed rates 3, 4, and 5 kg donum^{-1}, and the second factor had three tillage depths of 15, 20, and 25 cm, have been studied the bulk density of the soil, soil moisture content, germination rate, number of fallen seeds, and percentage of broken grains. The experiment used a randomized complete block design (RCBD) with split-plot arrangement and three replications. The least significant difference (LSD) at a significance level of 0.05 was used to compare the means of the treatments. The results indicate significant differences in the physical soil properties due to plowing depth and seeding rate. A plowing depth of 15 cm resulted in the soil's lowest bulk density, reaching 1.02 µg m^{-3}. It also resulted in the lowest soil moisture content (12.69%), germination rate (68.83%), and percentage of broken seeds (3.77%). The results indicated no significant differences in the physical soil properties due to the seeding rate and no significant interaction in the physical soil properties between plowing depth and seeding rate.

Keywords: Bulk density, soil moisture content, germination rate, broken grains.

دراسة تأثير الة مركبة ثمانية الغرض في بعض صفات التربة الفيزيائية

***اسلم محمد حسين كريم*[1] ، *عبد الرزاق عبد اللطيف جاسم*[2]**

1 قسم المكائن والآلات الزراعية، كلية علوم الهندسة الزراعية، جامعة بغداد، بغداد، العراق، **Aslam.kareem2103m@uobaghdad.edu.iq**

2 الاستاذ الدكتور، قسم المكائن والآلات الزراعية، كلية علوم الهندسة الزراعية، جامعة بغداد ، بغداد، العراق Abdulrazzak.Jasim@coagri. uobaghdad.edu.iq

الخلاصة

نفذت تجربة حقلية لدراسة تاثير الة مركبة ثمانية الغرض مطورة ومجمعة محليا في بعض صفات التربة الفيزيائية في تربة مزيجة طينية غرينية في احد حقول كلية علوم الهندسة الزراعية /جامعة بغداد/الجادرية للموسم الزراعي الربيعي 2023. استخدم في التجربة جرار من نوع MF-650 وتضمن البحث دراسة عاملين الاول فيه ثلاث كميات للبذار(التقاوي) وهي 3و 4 و5 كغم. دونم-1 والعامل الثاني اعماق الحراثة وهي15 و20 و25 سم، تم دراسة الكثافة الظاهرية للتربة، المحتوى الرطوبي للتربة، نسبة الانبات، عدد البذور النازلة و نسبة عدد الحبوب المتكسرة. تم استخدام ترتيب الالواح المنشقة Split-Plot تحت تصميم القطاعات العشوائية الكاملة المعشاة(RCBD) وبثلاثة مكررات واستخدم اقل فرق معنوي (LSD) عند مستوى 0.05 لمقارنة متوسطات المعاملات وأشارت النتائج الى وجود فروق معنوية لصفات التربة الفيزيائية جراء عمق الحراثة وكمية البذار(التقاوي) اذ تفوق العمق 15 سم في اعطائه اقل

كثافة ظاهرية للتربة بلغت(1.02) ميكا غرام. م-3 واقل محتوى رطوبي للتربة بلغ (12.69 %) واقل نسبة انبات بلغت (68.83 %) واقل نسبة بذور متكسرة بلغت (3.77 %). وثبتت النتائج عدم وجود فروق معنوية في صفات التربة الفيزيائية جراء كمية البذار(التقاوي) وعدم وجود فروق معنوية في صفات التربة الفيزيائية جراء التداخل بين عمق الحراثة وكمية البذار(التقاوي).

الكلمات المفتاحية: الكثافة الظاهرية، المحتوى الرطوبي للتربة، نسبة الانيات، الحبوب المتضررة.

INTRODUCTION

Agricultural machinery is considered a fundamental component of modern agriculture due to its ability to control various factors affecting productivity, increase production, improve its quality, reduce costs, and minimize working hours by efficiently performing agricultural operations quickly. It also enables the cultivation of larger areas with different crops. Agricultural machinery is a key indicator of transitioning from traditional to modern agriculture **(Al-Tahan *et al*., 1991).**

The combined machine reduces soil compaction, improves soil physical properties, reduces time and operating costs, and prepares a good bed for seeds in a short time **(Frank *et al.*, 2012).** It is necessary to develop methods and techniques that do not negatively affect soil properties but rather improve the physical soil characteristics and reduce the negative impact of machinery and agricultural equipment, and the use of mechanical assembly, which involves using compound machines that perform all means of production in one, while reducing the entry of machinery and agricultural equipment into the field. **(Ahmed & Amran, 2004).**

The compound machine accomplishes multiple agricultural operations in one, and the compound machines contain primary equipment and secondary equipment, and crop servicing machinery. The compound d machine requires significant power, which must be available in the agricultural tractor to complete the agricultural operations. Plowing and seeding machines are the basis for the productivity of the crop to be cultivated **(Jasim, 2019; Al-Shukraji *et al.*, 2006).**

The plow sole or hard pan layer in the soil is considered one of the problems and obstacles that agricultural fields face in general, and crop productivity in particular, due to its direct negative impact on the physical properties of the soil. **(Gill & Vanden, 1968; Jasim & Abd, 1996).**

Maize (*Zea mays* L.) is the third most important cereal crop in terms of cultivated area and production, following wheat and rice, globally. It is considered a strategic crop that plays a significant role in the livelihood of the Iraqi people and contributes to the development of agro-industries. It also plays a crucial role in animal production by providing green and concentrated fodder **(Al-janabi *et al.*, 2023).** Many international organizations have emphasized the need to double production by the year 2050. This study was conducted in view of the importance of knowing the effect of the eight-purpose compound machine on some physical soil properties.

Maize is a versatile crop, allowing for its cultivation in a wide range of agricultural environments **(Al-Aridhee & Mahdi, 2022),** especially considering the current world population of 7.2 billion, expected to increase to approximately 9.2 billion by 2050 **(Tawfic, 2019).**

MATERIALS AND METHODS

A field experiment was conducted at one of the research stations of the College of Agriculture, University of Baghdad, Al-Jadriyah, in the year 2023 to evaluate the effect of a locally developed and assembled eight-purpose compound machine on some physical soil properties. Random samples were taken from the experimental field at depths of 0-30 cm, and the analyses were performed at the central laboratory of with the College of Agricultural Engineering Sciences, University of Baghdad, Al-Jadriya. The samples were analyzed to determine some field soil properties, as shown in Table (1).

Table (1): Physical and chemical properties of field soil.

Parameter	Unit		Value
Soil separates	Clay	gm kg^{-1}	390
	Sand	gm kg^{-1}	110
	Silt	gm kg^{-1}	500
Soil texture			Silty clay loam
pH			7.4
EC	ds.m^{-1}		3.7
Soil bulk density	Mg m^{-3}		
Soil moisture content At field capacity	%		42.62
Soil moisture content At wilting pint	%		20.62
Soil moisture content	%		2.62

The compound machine was used, which consists of several interconnected tools in one structure. It includes eight agricultural machines, namely the primary tillage machine, which utilizes a subsoil plow, the smoothing machine equipped with a rotary harrow, the furrow opener machine, the planting machine (seeder), the fertilizing machine, the first irrigation machine, the weed control machine, and the boundary leveling machine (Figure 1).

Rear view **Side view**

Figure (1): Rear view and front view of the compound machine.

The experiment used a randomized complete block design (RCBD) with a split-plot arrangement and three replications. Seed rates (3, 4, 5 kg $donum^{-1}$) were allocated to the main plot, while the tillage depth treatments (15, 20, 25 cm) were allocated to the sub-plot. The total number of experimental units was 27, with an area of 30 m^2 (10 x 3 m) each, was left a distance of 10 meters before each replicate, until the tractor gains a constant speed. The area of the experimental field was 350 m^2.

In the implementation of the experiment, a tractor of the type (MASSEY FERGUSON) of Brazilian origin (MF-650) was used to tow the compound machine, so that the tractor with the compound machine would be one unit.

Measurement of Studied Characteristics:

Bulk Density of Soil (Mg/m^3):

The bulk density was calculated using the Core Sampler Method based on the equation proposed by **Blake and Hartge (1986).**

Pp = MS/Vt ---1

Where:

Pp = Bulk density (Mg m^{-3})

MS = Mass of the dry sample (1 Mg)

Vt = Volume of the sample (m^3)

Moisture Content of Soil (%):

The moisture content was measured using the following equation proposed by **Gardner (1965).**

$$Mc = \frac{Msw - Ms}{MS} \times 100 \text{--} 2$$

Where:

Mc = Moisture content of the soil (%)

Msw = Mass of the wet soil (g)

Ms = Mass of the dry soil (g)

Germination Ratio (%):

Several factors, such as seeds type, size, and planting depth affect germination ratio. The field germination ratio was measured after 20 days of planting by calculating the number of seeds required for one theoretical hectare and monitoring the actual seeds planted. The following equation, proposed by **Baqer (2011),** was used to determine the field germination ratio.

$$GR = \frac{\text{Number of germinated seeds in the experimental unit}}{\text{Number of seeds planted in that unit}}\ x\ 100 \text{------------------------} 3$$

Where:

GR = Germination Ratio (%)

Percentage of Broken Seeds (%):

It was calculated according to the method proposed by **Mohammed (2019)** and **Al-Banna (1990).** Samples were collected after passing through the feeding mechanism and through bags placed at the end of four randomly selected seed tubes from the planting lines. At the end of each experimental unit, and with different studied factors (seeding rate and tillage depth), the number of seeds that fell from the tubes was manually counted for four bags per experimental unit. Then, the number of damaged seeds was manually counted for each bag, and the percentage of broken seeds was calculated using the following equation:

$$DG = \frac{ND}{Nt} X\, 100 ---------4$$

Where:
DG: Percentage of broken seeds (%)
Nd: Total number of broken seeds
Nt: Total number of seeds

RESULTS AND DISCUSSION

Bulk Density (Bb) (μg m^{-3}).

The results indicate significant differences between tillage depths on the bulk density of soil. Increasing the depth leads to an increase in the bulk density of the soil. The bulk density at the first depth (15 cm) had the lowest value of 1.02 Mg m^{-3}. The second depth (20 cm) recorded an average bulk density of 1.04 Mg m^{-3}, while the third depth (25 cm) had the highest average bulk density of 1.15 Mg m^{-3}. The reason for this is that increasing the average depth increases the pressure on the soil due to the load applied by the machine and the weight of the soil layers on top of each other, resulting in an increase in soil compaction due to the subsoil layers and consequently an increase in bulk density. These results are consistent with the findings of **Menkhi and Jebur (2022) and Aridhee *et al.* (2020).**

It was also clear from the results a significant interaction between seeding rate and tillage depth. The lowest value of soil bulk density was recorded at a first seeding rate (3 kg donum) and tillage depth of 15 cm at 1.02 Mg m^{-3}, while the highest soil bulk density was recorded for third seeding rate of 5 kg donum^{-1} and tillage depth of 25 cm at 1.19 Mg m^{-3}.

Table (2): Effect of plowing depth and seeding amount on soil bulk density (Mg m^{-3})

Seeding rate kg donum^{-1}	Tillage depth (cm)			Mean seeding rate
	15	20	25	
3	1.02	1.04	1.15	1.07
4	1.05	1.08	1.11	1.08
5	1.10	1.14	1.19	1.14
LSD $_{0.05}$	0.081			N.S
Mean tillage depth	1.06	1.08	1.15	
LSD $_{0.05}$	0.073			

2- Soil Water Content (%)

The results revealed a significant effect of tillage depth on soil water content (Table 3). It is observed that an increase in average depth leads to an increase in soil water content. The first average depth recorded a moisture content rate of 14.10%, while the second average depth recorded a moisture content rate of 15.18%. The third average depth recorded the highest moisture content value at 16.52%. Additionally, the result indicates no significant effect of seeding rate on soil water content. It was also clear from the results that there were significant differences in the moisture content of the soil due to the interaction between the first seeding rate (3 kg donum^{-1}). and the depth of the first plowing of 15 cm, as they recorded the lowest soil moisture content of 12.69%, and the third seeding rate (5 kg. Donum^{-1}) and the third plowing depth of 25 cm, as they recorded the highest soil moisture content of 17.24%.

Table (3): Effect of plowing depth and seeding amount on Soil water content (%).

Seeding rate kg donum^{-1}	Tillage depth (cm)			Mean seeding rate
	15	20	25	
3	12.69	13.85	15.89	14.14
4	13.74	15.70	16.46	15.30
5	15.90	16.02	17.24	16.39
LSD $_{0.05}$	1.01			N.S
Mean tillage depth	14.11	15.19	16.53	
LSD $_{0.05}$	0.73			

3 - Germination Percentage (%)

The result shows a significant effect of the seeding rate on germination percentage. It is observed that the first seeding rate (3 kg ha^{-1}), recorded the lowest average germination percentage at 71.58%. The second seeding rate (4 kg ha^{-1}), recorded an average germination percentage of 80.58%. The third seeding rate (5 kg ha^{-1}) recorded the highest average germination percentage at 88.89%. The reason behind this is that the germination percentage increases with an increase in seeding rate and to an increase in the forward speed of the tractor **(Omar *et al.*, 2021)**. Additionally, the result indicates no significant effect of tillage depth. The results also indicate that there was a significant difference in the percentage of germination due to the interaction between the first seeding rate (3 kg. Donum^{-1}) and the first plowing depth of 15 cm, as they recorded the lowest percentage of germination amounting to 68.83%, and the third seeding rate of 5 kg. Donum^{-1} and the third plowing depth of 25 cm, as they recorded the highest percentage of germination, at 93.75%.

Table (4): Effect of plowing depth and seeding amount on germination (%).

Seeding rate kg donum^{-1}	Tillage depth (cm)			Mean seeding rate
	15	20	25	
3	12.69	13.85	15.89	14.14
4	13.74	15.70	16.46	15.30
5	15.90	16.02	17.24	16.39
LSD $_{0.05}$	1.01			N.S
Mean tillage depth	14.11	15.19	16.53	
LSD $_{0.05}$	0.73			

4- Broken Seed Percentage (%)

Table 5 demonstrates the effect of tillage depth and seeding rate on the percentage of fallen, broken seeds. The result reveals significant differences in the percentage of fallen broken seeds, and this is due to an increase in seeding rate (kg donum^{-1}) per unit area. The average number of broken seeds in the first seeding rate of 3 kg dunum-^{1} was 4.84% , and for the second seeding rate of 4 kg dunum^{-1} was 6.04%. While for the third seeding rate of 5 kg dunum-^{1} resulted in a higher percentage of fallen broken seeds at 12.68%. The result indicates no significant effect of tillage depth on the seeding rate (kg/ha). The results also indicate significant differences in the percentage of broken seeds due to the interaction between the first seeding rate of 3 kg donum^{-1}and the depth of the first plowing of 15 cm, with the lowest percentage of broken seeds at 3.77%. Furthermore, between the third seeding rate of 5 kg per donum^{-1} and the depth of the third plowing of 25 cm, with the highest percentage of broken seeds was at 14.78%.

Table (5): Effect of plowing depth and seeding amount on Broken Seed Percentage (%).

Seeding rate kg donum^{-1}	**Tillage depth (cm)**			**Mean seeding rate**
	15	20	25	
3	3.77	4.72	6.02	4.84
4	4.26	6.23	7.65	6.04
5	10.02	13.25	14.78	12.68
LSD $_{0.05}$	3.913			4.854
Mean tillage depth	6.02	8.06	9.48	
LSD $_{0.05}$	N.S			

CONCLUSIONS AND RECOMMENDATIONS:

Based on the above results, the following conclusions can be drawn. The successful use of the compound machine in executing eight agricultural tasks at the same time, included primary plowing, cultivation, furrow opening, planting, fertilization, initial irrigation, weed control, leveling, and achieving a maximum depth of 15 cm with lower bulk density, moisture content, germination rate, and broken seed percentage. There was no significant effect of the seeding rate on the physical soil properties. Therefore, we recommend the use of the combined machine to execute eight agricultural tasks simultaneously, including primary plowing, secondary plowing (cultivation), furrow opening, planting, fertilization, initial irrigation, weed control, and leveling, for its ability to reduce effort, optimize time, and minimize fuel consumption. We also recommend measuring other characteristics of the machine in different soil textures.

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