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RESEARCH ARTICLE
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Studying some mechanical indicators of grain drill at different soil moisture and seeding speed.

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ABSTRACT

The experiment was carried out during the growing season (2023-2024) at a farmer's field in Baweiza / Telkif, northwest of Mosul city, which is located within the Semi-Arid (36°27'17.8"N 43°04'51.9" E). Where the rain amount reached 279 mm. The field soil was characterised as a Silt-Loamy soil texture. A Turkish modern disk grain drill was used in the experiment (Skalak), which is manufactured specifically for conservation agriculture, for seeding wheat grains. The experiment included three factors: the first was soil moisture with two high levels of 23% and an ideal moisture level of 17%; the second was three seeding speeds (8.3, 10.3 and 12 km/h); and the third was seeds coverage tool (with and without press wheels), the experiment was established using a Randomized Complete Block Design (RCBD) under split-split plot system, where the moisture factor occupied main plots, seeding speed was assigned to sub-plots, and sub-sub-plots were used for seeds coverage tool. The Duncan multiple range test compared means at a 0.05 significance level. The following traits were studied: Slippage percentage, soil adhesion strength, actual soil disturbance volume, and grain yield. The important results are that the ideal soil moisture of 17% achieved significant improvements in all studied qualities compared to high soil moisture of 23%. The results also indicated a significant effect at a speed of 12 km/h, where the highest value of slippage, soil disturbance volume, grain yield, and the lowest soil adhesion strength were recorded. The use of press wheels achieved a significant positive difference in soil adhesion strength, while not using press wheels led to a significant improvement in the slippage percentage. The results showed that the triple interaction between moisture content, seeding speed and seed pressure wheels did not significantly differ in the studied characteristics (slippage percentage, actual soil disturbance volume, and grain yield). However, it was found that there was a significant effect in reducing the value of adhesion force at ideal humidity with a speed of 12 km / h using seeds press wheels.

***Keywords*:** soil moisture, covering mechanism, disc drill, speed.

INTRODUCTION

High soil moisture can lead to soil erosion and the release of exudates from fungi and bacteria, which negatively affect seed germination. Excessive water accumulation around the seeds can cause rotting and impair their ability to germinate. At the same time, optimal moisture provides a suitable environment for germination by providing a sufficient amount of water for imbibition without overhydrating the seeds [1]. High speed of seeding practices can affect a crop's ability to grow consistently, reduce the final yield and cause poor seed coverage. These issues may ultimately result in germination problems [2]. It has been scientifically proven that adding coverage type (press wheels) into modern grain drills leads to a successful seeding process if appropriate conditions and factors are available in the field [3] [4] stated that the increase in the slippage rate occurs when the speed is increased to 14 km / h, while [5] indicated that the speed of 8 km / h is appropriate in reducing the slippage value because when increasing the speed, the slippage rate increases due to reduce the contact time between the soil and the tires. [6] indicated that soil moisture above 17% results in the lowest slippage value compared to the soil moisture of 20% when using the sweep tine. [7] indicated that there is an increase in soil adhesion strength by increasing the moisture content to a certain amount, and then it decreases again. That high moisture content increases the working time and consumption of many parts of the disc grain drill and can be reduced by adding special polymeric plastics on the discs and other parts to reduce the adhesion force [8]. [9] stated that increasing moisture content above the ideal content leads to increased slippage in field work and thus reduces actual speed, which leads to a decrease in practical productivity and finally a decrease in soil disturbance volume. [10] showed in their study of some field factors that there is a clear, significant increase in grain yield when using press wheels compared to not using them. [11]

revealed that the best or highest yield was recorded at 8 km / h, while the lowest yield was at 11 km / h. Recent use of disc grain drills in conservation agriculture in the northern governorates has led to some emergence problems in their use, especially under conditions of high soil moisture content, which may lead to blockages in seed feeding holes and fertilizer distribution. Moreover, a lack of appropriate information about the types of seed grain drills and the benefits of press wheels. Thus, this study was necessary to address these challenges.

Materials and Methods

The experiment was carried out during the growing season (2023-2024) at a farmer's field in the Bawaiza area of Nineveh Governorate within the semi-arid area (36°27'17.8"N 43°04'51.9"E), and the land was not cultivated in the previous season. The experiment soil texture was analyzed as a Silt-Loam soil texture, and the average rain amount during the season was 279 mm. A tractor model Fiat 130 four-wheel drive was used in the processes (sowing and fertilization). The experiment was cultivated by a modern disc grain drill specialized for conservation agriculture (SAKALAK), where the land is not plowed before planting, and the seeding process is carried out directly (ZT system). The grain drill's type was disc; it had a working width of about 300 cm, with a distance between the lines of 15 cm, and a total of 20 lines. Also, the grain drill had modern calibration equipment that differed from traditional grain drills. The seeding rate was 100 kg/ha. The land was prepared by dividing it into two parts according to moisture content (high moisture content and ideal moisture content). The experiment included three factors: the first was soil moisture with two high levels (high at23% and ideal at 17%), the second factor was three seeding speeds (8.3, 10.3 and 12 km /hour), and the third factor was the seeds coverage tool (with and without press wheels), the factorial experiment was established by using a Randomized Complete Block Design (RCBD) under a split-split plot design [12]. To experiment, the main plots were allocated to moisture content. Each main plot was divided into three subplots, which were allocated to seeding speed, and each subplot was divided into sub-subplots, which were allocated to press wheels. The experimental unit area was (3×30) m^2, while the total area of the experiment was 3600 m^2. After planning the experiment according to the prescribed design, the moisture content was monitored by using a device for measuring soil moisture percentage. After laboratory and field calibration, using the grain drill catalogue, the seeding was implemented.

Studied traits and measuring methods: -

Slippage percentage (%)

Slippage is defined as a discrepancy between the linear distance travelled and the circumferential distance covered by a fixed number of tractor drive-wheel revolutions. Typically, the linear distance is less than the circumferential distance [13].

$$SP\ \% = \left[\left(V_t - V_p\right)/V_t\right] \times 100 \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where:

SP = slippage percentage (%)

Vt = Theoretical Speed (km/h)

Vp = actual Speed (km/h)

Soil adhesion strength (kn/m^2)

After the treatment, the grain drill was lifted, and the adhered soil of each disc was removed, placed in a plastic bag, and then weighed. Adhesion strength was calculated according to the equation below [14]. The strength of the adhesion was measured by determining the weight of the dirt blocks attached to the disc blades and dividing this value by the total area of the disc

$$C = \frac{WS}{A} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where:

C = adhered soil strength on disc surface (kN/m^2),

WS = soil weight on disc surface (kN)

A = disc area (m^2)

Actual soil disturbance volume (m^3/h)

The distributed soil volume by the grain drill discs depends on the implement's practical productivity and the actual seeding depth. The soil disturbance volume can be calculated using the following equation [15].

$$S.V.D = EFC \times DP \times 100 \ldots\ldots\ \ldots\ldots\ldots (3)$$

Where:

S.V.D = soil disturbance volume (m^3/h)

EFC = actual productivity (ha/h)

DP = verified depth (m)

Yield kg/ha

The final stage of the experiment was yield calculation per hectare. After the growth of the ears was completed and it was completely dry, random samples were collected from the experimental units using a wooden board. Four replicates were collected using a sickle for all experimental units, threshed manually, weighed and converted to square meters, then adjusted to hectares.

Results and discussion

Table (1) shows that there are significant differences between moisture levels in the slippage percentage, where high moisture content, 23%, was recorded, the highest slippage rate of 22.188% compared to the ideal moisture content, 17%, which recorded a slippage rate of 16.477%. By reducing moisture content and reaching the soil physical maturity stage, the slippage will decrease, and planting can be delayed until the soil surface becomes ideal to achieve the best work efficiency by reducing the disc angle during planting [16] [17]. The 8.3 km/h speed recorded the lowest significant percentage of slippage, 13.341%, compared to the second and third speeds (19.558% and 25.100%) respectively. The reason behind that is increasing speed increases the slippage rate due to the reduction of the contact time between the soil surface and the tires. This was mentioned by [18], and [19].
Without cover wheels, the lowest percentage of slippage was recorded, 18.038%, compared to cover wheels, which recorded 20.627%. This is due to the cover wheels' weight and the machine's high weight, which increases the slippage rate, as indicated by [20]. The interaction between the moisture content rate of 23% and speeds of 10.3 and 12 km/h recorded the highest slippage rate (25.585 and 26.616) %, respectively. Meanwhile, a speed of 8.3 km/h with a moisture content rate of 17% recorded the lowest slippage of 12.316%, and no significant differences were observed between other interactions.

Table (1) Effect of soil moisture content, seeding speed and coverage type on slippage percentage %

Moisture average	Moisture× seeding speed	coverage type		Seeding speed	Moisture
		With press wheels	Without press wheels		
	14.366 c	15.533 a	13.200 a	8.3	
22.188 a	25.583 a	27.000 a	24.167 a	10.3	23%
	26.616 a	27.367 a	25.867 a	12	
	12.316 c	14.433 a	10.200 a	8.3	
16.477 b	13.533 c	14.500 a	12.567 a	10.3	17%
	23.583 b	24.933 a	22.233 a	12	
	seeding speed average	23.300 a	21.077 a	23%	Moisture × coverage type
		17.955 a	15.00 a	17%	
	13.341 c	14.983 a	11.700 a	8.3	seeding speed × coverage type
	19.558 b	20.750 a	18.366 a	10.3	
	25.100 a	26.150 a	24.050 a	12	
		20.627 b	18.038 a	coverage type average	

The lowest value is the best

Soil adhesion strength (kN/m^2):

Table (2) shows a clear significant increase in soil adhesion strength at high moisture content, 23%, which records 0.034 kn/m2, compared to the ideal moisture, 17%, which recorded 0.019 kn/m^2. This shows that as the moisture content increases, the adhesion strength on the machine working part surface increases, adhering with minimal due to wet soil particles. Thus, it forms bonded layers between working parts and soil, as referenced by [4] [21]. The highest significant value of soil adhesion strength was found for speed of 8.3 km/h, amounting to 0.031 kN/m^2 compared to the 10.3 and 12 k/h speeds (0.026, 0.023) kN/m^2, respectively. This is attributed to the high tractor velocity, which increases soil clods splashing from working surfaces more than the slow speeds, thereby preventing water accumulation. This indicates that increasing speed decreases soil adhesion strength [22]. Adhesion strength without covering wheels recorded the highest value, 0.029 kn/m2, compared to the use of covering wheels, which recorded 0.024 kn/m^2, as shown by [23]. Soil adhesion with grain drill parts may reduce seeding quality. Significant differences were mentioned for the interaction between the studied factors according to the Duncan test. In cases where the speed of 8.3 km/h was applied, the highest soil adhesion strength occurred at 23% moisture content and without covering wheels, recording the highest adhesion strength (0.045) kN/m^2. The Interaction between ideal moisture, 12 km/h speed and covering wheels recorded the lowest adhesion strength (0.014) kn/m^2. Ideal moisture content combined with high speed reduces soil adhesion strength with grain drill parts, as mentioned by [24].

Table 2 Effect of soil moisture content, seeding speed and covering type on adhesion strength characteristic (kN/m2)

Moisture average	Moisture× seeding speed	coverage type		seeding speed	Moisture
		With press wheels	Without press wheels		
	0.04 a	0.037 bc	0.045 a	8.3	
0.034 a	0.033 b	0.025 def	0.041 ab	10.3	23%
	0.029 b	0.027 de	0.031 dc	12	
	0.021 c	0.021 efg	0.022 efg	8.3	
0.019 b	0.020 c	0.019 efg	0.020 efg	10.3	17%
	0.016 c	0.014 g	0.018 fg	12	
	seeding speed average	0.030 b	0.039 a	23%	Moisture × coverage type
		0.018 c	0.020 c	17%	
	0.031 a	0.029 a	0.034 a	8.3	seeding speed × coverage type
	0.026 ab	0.022 a	0.030 a	10.3	
	0.023 b	0.021 a	0.025 a	12	
		0.024 b	0.029 a	coverage type average	

The lower value is the best

Soil disturbance volume (m^3/h)

Table (3) shows that the high moisture content 23% recorded the lowest significant value of 652.54 m^3/h compared to the ideal moisture 17%, which recorded the highest value of 695.92 m^3/h, as confirmed by [25]. The third speed, 12 km/h, recorded the highest soil disturbance volume, reaching 742.14 m^3/h, compared to the other speeds. Soil disturbance volume increases with increasing tractor speed, because it is one of the productivity components for soil disturbance volume calculation, as pointed out by [26]. The table also indicated no significant effects between press wheel levels. The interaction treatment between moisture 17% and seeding speed of 12 km/h recorded the highest raised soil volume of 779.81 m^3/h, while the same soil moisture with the first speed (8.3 km/h) achieved the lowest value of 572.05 m^3/h. This aligns with [9], which states that increasing moisture content can reduce process speed, and a slower speed decreases soil disturbance volume.

Interaction between the third speed, 12 km/h, and press wheels exceeded 760.03 m3/h, compared to other treatments, while the first speed, 8.3 km/h, without press wheels, recorded the lowest soil disturbance volume, 555.75 m^3/h. The effect of seeding speed was clear, more than the impact of the press wheel, with higher seeding speed increasing soil disturbance volume, as indicated by [19].

Table (3) Effect of soil moisture content, seeding speed and covering type on soil disturbance volume m3/h

Moisture average	Moisture × Seeding speed	coverage type: With press wheels	coverage type: Without press wheels	Seeding speed	Moisture
	587.23 b	591.00 a	575.47 a	8.3	
652.54 b	669.92 a	631.07 a	708.77 a	10.3	23%
	704.47 ab	711.07 a	697.87 a	12	
	572.05 b	608.07 a	536.03 a	8.3	
695.92 a	735.88 a	713.97 a	757.89 a	10.3	17%
	779.81 a	809.00 a	750. 63 a	12	
	Seeding speed averag	644.38 a	660.70 a	23%	Moisture × coverage type
		710.34 a	681.49 a	17%	
	577.64 b	599.53 c	555.75 c	8.3	seeding speed × coverage type
	702.90 a	672.52 b	733. 28 a	10.3	
	742.14 a	760.03 a	724.25 ab	12	
		677.36 a	671.09 a	coverage type average	

The lower value is the best

Grain yield (kg/ha):

Table (4) clearly shows high significant effects of moisture levels in grain yield, where high moisture levels (23% recorded the lowest significant yield of 1920.55 kg/ha, compared to the ideal moisture level (17%, which recorded the highest yield of 2119.44 kg/ha. The reason is that high moisture content leads to seed rotting before germination, thereby reducing grain yield [27].

The first speed, 8.3 km/h, recorded a lower yield of 1879.17 kg/ha compared to 10.3 and 12 km/h, while the second and third speed levels had the same level of significance (2077.50, 2103.33) kg/ha, respectively. This indicates that grain yield can increase with increasing speed, which is useful for determining the best speed for cultivation, as indicated by [5].

The table also indicated that there are significant effects of coverage type levels on grain yield, where without covering wheels, grain yield recorded the lowest amount, 1991.67 kg/ha, compared to the use of covering wheels, which recorded 2048.33 kg/ha. Yield amount increased when wheels have been used, and this is linked to the positive impact of plants/m^2 and improved grain yield, as referred by [28].

High moisture content, 23% at 8.3 km/h speed, recorded the lowest yield 1798.33 kg/ha, while the second speed, 10.3 km/h with 17 % moisture content, achieved the highest yield 2236.67 kg/ha. This was better than the third speed, which recorded (2161.67) kg/ha, which means that high speed may lead to a difference in seeding depth during cultivation, as supported by [29].

Interaction between speed and coverage type, the speed 8.3 km/h and without covering wheels recorded the lowest grain yield 1791.67 kg/ha, compared to the use of covering wheels, which recorded 1966.67 kg/ha. While the interaction between speed 12 km/h and without covering wheels recorded the highest significant grain yield, 2111.67 kg/ha, the use of covering wheels recorded 2095.00 kg/ha.

Table (4) Effect of soil moisture content, seeding speed and coverage type on the total grain yield kg/ha

Moisture average	Moisture× seeding speed	coverage type: With press wheels	coverage type: Without press wheels	seeding speed	Moisture
	1798.33 d	1756.67 a	1740.00 a	8.3	
1920.55 b	1918.33 c	1910.00 a	1926.67 a	10.3	23%
	2045.00 b c	2066.67 a	2023.33 a	12	
	1960.00 c	a 2076.67	1843.33 a	8.3	
2119.44 a	2236.67 a	2256.67 a	2216.67 a	10.3	17%
	2161.67 a	2123.33 a	2200.00 a	12	
	seeding speed average	1944.44 a	1896.67a	23%	Moisture × coverage type
		2152.22 a	2086.67 a	17%	
	1879.17 b	1966.67 b	1791.67 c	8.3	seeding speed × coverage type
	2077.50 a	2083.33 a	2071.67 a	10.3	
	2103.33 a	2095.00 a	2111.67 a	12	
		2048.33 a	1991.67 b	coverage type average	

The higher value is the best

Conclusion

From the above, optimal soil moisture (17%) and moderate seeding speeds (10–12 km/h) maximised grain yield (up to 2236.67 kg/ha) and operational efficiency while minimising slippage (16.477%) and soil adhesion (0.019 kN/m²). Press wheels enhanced yield but required careful calibration to offset slippage risks. Integrated management of moisture, speed, and machinery design is critical for sustainable conservation agriculture in semi-arid regions. Future innovations in material coatings and precision calibration are recommended to address adhesion challenges and refine seeding depth consistency.

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دراسة بعض الصفات الميكنية للباذرة عند رطوبة تربة وسرع بذار مختلفة.

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[4] مديرية زراعة نينوى

الخلاصة

نفذت التجربة في الموسم الزراعي (2023-2024) في أحد حقول المزارعين بمنطقة بعويزة / تلكيف، الواقعة شمال غرب مدينة الموصل، والتي تقع ضمن المناطق شبه مضمونة الامطار، حيث بلغت كمية الامطار (279) ملم. تميزت تربة الحقل بنسجة مزيجية غرينية. استخدمت في التجربة الباذرة القرصية الحديثة (*SAKALAK*) تركية المنشأ، المصنعة خصيصا للزراعة الحافظة، حيث تم زراعة محصول الحنطة بها تضمنت التجربة ثلاث عوامل العامل الأول هي الرطوبة بمستويين: الاول بمعدل 23% والثاني رطوبة مثالية بمعدل 17% ، والعامل الثاني هو ثلاث سرع لعملية البذار (8.3، 10.3 و12) كم /ساعة ، والعامل الثالث الية التغطية والضغط (بدون استخدام عجلات الضغط ومع استخدامها) وفق نظام تصميم القطاعات العشوائية الكاملة (*RCBD*)واستخدمت طريقة الالواح المنشقة- المنشقة حيث خصصت الالواح الرئيسية للمحتوى الرطوبي. والالواح الثانوية لسرع عملية البذار والالواح تحت الثانوية لالية التغطية (وجود عجلات الضغط وبدونها)، واختبرت متوسطات النتائج بطريقة دنكن المتعدد المدى عند مستوى احتمال (0.05). وتمت دراسة الصفات الأتية :(نسبة الانزلاق %، قوة التصاق التربة كيلو نيوتن/م^2، حجم الاثارة الفعلي للتربة م^3/هكتار، حاصل الحبوب كغم/هكتار)، حققت الرطوبة المثالية 17 % تفوق معنوي لجميع الصفات المدروسة بالمقارنة مع الرطوبة العالية 23%. كما اشارت النتائج الى التأثير المعنوي عند السرعة 12 كم/ساعة؛ حيث سجلت اعلى قيمة في الانزلاق، وحجم التربة المثار، وحاصل للحبوب، واقل قوة التصاق للتربة. وحقق استخدام عجلات التغطية فرقاً معنوياً ايجابياً في قوة الالتصاق، في حين ان عدم استخدام عجلات التغطية أدى الى تحسين معنوي في نسبة الانزلاق ويعود السبب الى وزن عجلات التغطية وزيادة الحمل الواقع على الالة. وتفوقت الرطوبة المثالية مع استخدام عجلات الضغط او بدونها، معنوياً بأقل قوة التصاق بالتربة كما أظهرت النتائج أن التداخل الثلاثي بين المحتوى الرطوبي وسرع البذار وآلية التغطية لم يسفر عن فروقات معنوية في الصفات المدروسة (نسبة الانزلاق، حجم التربة المثار، وحاصل الحبوب) في حين تبين وجود تأثير معنوي في تقليل قيمة قوة الالتصاق عند الرطوبة المثالية مع السرعة 12 كم /ساعة باستخدام عجلات التغطية.

الكلمات المفتاحية: رطوبة التربة ، الية التغطية ،الباذرة القرصية ، السرعة.