Tikrit Journal for Agricultural Sciences
ISSN:1813-1646 (Print); 2664-0597 (Online)
Journal Homepage: http://www.tjas.org
E-mail: tjas@tu.edu.iq

TJAS
Tikrit Journal for Agricultural Sciences

DOI: https://doi.org/10.25130/tjas.25.4.15

A Comparative Analysis of Iron and Pneumatic Tires in Conventional Seed Drill Operations

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KEY WORDS:
depth of seeding, forward speed, types of tires, Agricultural tractors

Received: 01/02/2025
Revision: 21/08/2025
Proofreading: 22/10/2025
Accepted: 30/09/2025
Available online: 31/12/2025

ABSTRACT

The research was conducted in Dwgwndany Gawra, Daratoo, Bardarash, Duhok, Iraqi Kurdistan Regional from December 5th to 10th, 2022. The experiment aimed to investigate the effects of different types of tires of a conventional disc seed drill, depth of seeding, and tractor forward speed on the amount of fuel consumption and time requirement. Factorial Randomized Complete Block Design (RCBD) was carried out. A 1989-121 2WD Anter tractor was used for carrying out the purposes The study was carried out in a clay soil texture with a 15.27% soil moisture content and dry bulk density of 1.40 (gram/ cubic cm). Pneumatic and ironic tires were considered types of tires, while 2 and 4 cm were considered depth and 7 and 10 km/h as forward speed. The outcomes of the study indicated that lower and higher amounts of fuel were consumed with pneumatic tires at a depth of 2 cm at the speed of 7 km/h and ironic tires at a depth of 4 cm at the speed of 10 km/h respectively. The tractor with ironic tires at a depth of 4 cm at a speed of 10 km/h increased fuel consumption by approximately 25 %. In terms of time requirement minimal time was required in the depth of 2 cm at both levels of forward speed and types of tires the difference was approximately under 5%.

مقارنة بين الإطارات الحديدية والهوائية لباذرة البذور التقليدية وعلاقتها باستهلاك الوقود والوقت اللازم في إقليم كوردستان العراق

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الخلاصة

تم إجراء البحث في احدى الحقول القرية دوكوندان كبير ، داراتو ، بردرش ، دهوك ، إقليم كوردستان العراق في الفترة من اليوم الخامس إلى اليوم العاشرة من الشهر الكانون الأول في السنة 2022. هدفت التجربة إلى معرفة تأثير أنواع مختلفة من الإطارات للباذرة القرص التقليدي ، وعمق الزراعة. ، والسرعة الأمامية للساحبة على مقدار استهلاك الوقود ومتطلبات الوقت. تم تنفيذ تصميم القطاعات العشوائية الكاملة العاملية (RCBD). تم استخدام ساحب عنتر 1989-121 دفع الثنائي لأغراض العملية التجربة. أجريت الدراسة في تربة طينية ذات محتوى رطوبة تربة 15.27% وكثافتها الظاهرية الجافة 1.40 (جرام/سم مكعب). اعتبرت الإطارات الهوائية والحديدية من أنواع الإطارات ، بينما اعتبر 2 و 4 سم عمق و 7 و 10 كم / ساعة كسرعة أمامية. أشارت نتائج الدراسة إلى أنه تم استهلاك كميات أقل وأعلى من الوقود مع الإطارات الهوائية على عمق 2 سم بسرعة 7 كم / ساعة والإطارات الحديدية على عمق 4 سم بسرعة 10 كم / ساعة على التوالي. الساحبة المزود بإطارات حديدية على عمق 4 سم وبسرعة 10 كم/ساعة أدى إلى زيادة استهلاك الوقود بنسبة 25% تقريبًا. من حيث الوقت المطلوب ، كان الحد الأدنى من الوقت مطلوبًا في عمق 2 سم على كلا مستويي السرعة الأمامية وأنواع الإطارات ، كان الفرق أقل من 5٪ تقريبًا.

الكلمات المفتاحية: عمق البذر، السرعة الأمامية، أنواع الإطارات، الساحبات الزراعية.

INTRODUCTION

Farming tractors is one of the most common power source within agricultural fields (Ibrahim Kareem and Sven, 2019). Bell (1996) Stated that seeding operation and various agricultural operations are employed by agricultural tractor. There are sveral primary agricultural machinery including seed drills (Bell, 1996; Moitzi *et al.*, 2014; Sahay, 2004). Ground speed of agricultural tractor is one of the most crucial factor which affect the performance of field operations (Islam *et al.*, 2019; Lithourgidis *et al.*, 2006; Rashidi *et al.*, 2013; Safa *et al.*, 2010).

Accuracy of seed placement, conditions of soil structure and total yield productivity can be influenced by several factors in the modern agricultural mechization including types of seed drill and types of tire. (Parihar *et al.*, (2022) Reported that use of seed drills advances several advantages including uniform depth of seeding and plant spacing compared to the traditional broadcasting methods. Soil compaction and traction efficiency can also be improved if accurate types of tire be selected related to the condition of the seeding operation. Sustainable farming can be practiced within soil structure and soil aeration by using wider tires and decreasing tire pressure (ten Damme *et al.*, 2020). Thus, selecting accurate types of tire and appropriate seed drills according to the standards of modern agricultural mechanization technologies can recover soil structure and build-up yield productivity.

Ibrahim Kareem and Sven (2019) indicated that the amount of fuel consumed was significantly increased when the forward speed was raised from 7 km/h to 10 km/h. Conversely, fuel consumed was decreased at the same speed when the plowing depth was increased from 15 cm to 20 cm. These findings suggest that optimizing forward speed and seeding depth can contribute reduce fuel consumption in agricultural machinery. In contrast Damanauskas *et al.*, (2019); Narendra *et al.*, (2014) reported that an increase in the seeding depth, requires a greater amount of fuel. Oduma *et al.*, (2022) Reported that fuel consumption decreased approximately 50% when the depth of working depth was switched from 30 cm to 10 cm.

Battiato & Diserens, (2017); Damanauskas *et al.*, (2015) Reportd that tractor engines consumed less fuel when equipped with pneumatic tires compared to the iron tires. Their study highlighted side force and high horizontal vibration during seeding as the main limitations of pneumatic tires. In contrast, iron tires apply a destructive impact paved roads during transportation due to their sharp edges, contrasting pneumatic tires which cause significantly less surface damage. Furthermore, the operational area can be covered in a short time when pneumatic tires are used, and the tractor requires less fuel to perform the same duties (Fanigliulo *et al.,* 2022; Hoy *et al.,* 2014). Similarly, Narendra *et al.,* (2014) indicated that a seed drill equipped with pneumatic tires can operate more efficiently, covering an given area in less time and lower fuel consumption. Pneumatic tires, compared to the other tire types maintain reduced contact with the ground surface. Janulevičius *et al.,* (2019) Indicated that development and optimizing of agricultural machinery are two of the main crucial factors to reduce energy consumption and saving time. Therefore, if pneumatic tires be used for seed drills, time can be saved and the cost of the operational can also be lowered. KADHIM & IDHAS, (2017) Further emphasized that the primary factors influencing fuel consumption are the working depth and forward speed of the tractor. Working depth can be described as the vertical dictance between two points which are the surface of soil and lowest cutting point of the soil by share or disc of the seed drill. Relatedly, tractor forward speed can also be defined as the cutting distance in the given periods of the time by tractor. Tuse, fuel consumtion can be reduced by optimaizing tractor forward speed and working depth during seeding operation.

This study involves three hypotheses. First, the tractor engine consumes additional fuel if the iron tire is attached to the seed drill instead of the pneumatic tire at the constant planting depth and rolling speed of the tractor. Second, the amount of fuel consumed by the tractor engine reduces if the tractor speed increase. Finally, the amount of consuming fuel will be higher if depth of ploughing be increased. The objective of this study is to determine the impact of two different tire tpyes of a conventional seed drill on the amount of fuel consumption by the engine of the tractor and covering time per unit of area under different levels of working depth and tractor forward speed.

MATERIAL AND METHODS

A Factorial Randomized Complete Block Design (RCBD) was applied to analyze the hypothesized factors of this study which are seeding depth, tractor forward speed, and tire types on the performance of a conventional seed drill and fuel consumption. The experiment involved thirty two units. 2 levels of seeding depth, 2 levels of tractor forward speed, 2 tire types, and 4 replications were the structures of the expermintal units. 2 and 4 cm were set as the levels of seeding depth, although 7 km/h and 10 km/h were the tractor forward speeds. Two type of tires were used during seeding which were iron and pneumatic tires. The length of one experimental unit was 40 meters, while the operational working width of the seed drill remaining 3 meters.

The study was performed in the field of Dwgwndany Gawra from December 5th to 10th, 2022. Dwgwndany Gawra is a village located in the Kurdistan Region of Iraq. The experiment was carried out in the couldy condition at the temperature ranged between 7° C to 16° C. Total area of each experiment was 120 m² (40 m × 3 m). Safty gape about 10 meters at the beging of experimental units was considerd to reach the required forward speed and seeding deth. The soil texture of Dwgwndany Gawra is clay with (37% sand, 10% silt, and 53% clay). The soil moisture content was 15.27%, and the dry bulk density was 1.40 g.cm-3 individually. An Anter 1989-121 2WD tractor was used for seeding operation (Figure 1 and 2). Appropriate information about the tractor are shown in Table 1. A graduated cylinder was adapted as a technical method to measure fuel consumption and the same method were used by Hunt, (2001); Hussein, (2020). After each run the graduated cylinder was refiled and consumed amounts of fuel was recorded. The tractor runs at low gear levels 3 to both levels of tractor forward speed respectively.

Table 1 Tractor specification

Specification	**Details**
Name	Anter 121
Model	1989
Number of cylinders	Six
Capacity of engine	5.25 liter
Engine power at 2000 rpm	43.3 kilowatt (58 hp)
Transmission:	10-speed
Weight	2950 kg
Cooling system	Water-Cooled
Rear tire	STARMAXX 18.4-34
Inflation Pressure	1.40 bar
Front tire	STARMAXX 7.50-20
Inflation Pressure	2.75 bar

At the outset of the experiment, several calibration procedures were performed, specifically for seeding depth and tractor forward speed. The mechanical lifting adjusting mechanism of the seed drill was used to set seeding depth levels. A measuring tap was also used to ensure the adjustment working depth accuracy. In contrast, the hand throttle of the tractor was used to calibrate forward speed of the tractor and achieve required speeds. The actual working time of individual experimental unit was recorded by using two cell phones, which were set to the same time to ensure measurement accuracy and consistency.

Figure 1 Tractor and conventional seed drill with pneumatic tires

Figure 2 Tractor and conventional seed drill with Ironc tires

A conventional seed drill equipped with two types of tires, namely iron and pneumatic, was employed for sowing wheat (*Triticum* spp.) (Figures 1 and 2). The seed drill consisted of 12 discs, each with a diameter of 65 cm and a disc edge thickness of 0.5 cm. The implement had a theoretical and actual working width of 300 cm, a disc plowing angle of 45°, and a tilt angle of 0°. The weight of the seed drill was 900 kg, while the seed drill with filled pulse seeds weighed approximately 1300 kg.

For time measurement, two operators were positioned at the starting and ending points of each experimental plot. The first operator recorded the beginning time of each experimental unit using a mobile phone, while the second operator recorded the ending time in the same manner. The operational time for all experimental units was determined using this synchronized approach (Equation 1). Microsoft Excel software was employed to calculate the working time of the experimental units. The experiments involving iron-tire and pneumatic-tire configurations were conducted separately to ensure measurement accuracy and prevent cross-interference.

Time Requirement (h) = Time of Second Cell Phone (h) – Time of First Cell phone (h)

Equation 1 Time requirement of each experiment unit.

RESULTS AND DISCUSSION

An analysis of variance (ANOVA) was conducted using a general treatment structure in randomized blocks at a 0.05 probability level of error (Table 2). The Duncan multiple range test (DMRT) was applied to determine statistically significant differences among treatment means for fuel consumption and time requirements.

The results presented in Table 2 revealed significant differences among the levels of tractor forward speed ($p = 0.046$). Seeding depth also exhibited a highly significant effect ($p = 0.000$). Similarly, the tire type of the seed drill had a statistically significant influence ($p = 0.000$). The interaction between tractor forward speed and seeding depth showed a significant effect ($p \approx 0.050$), while the interaction between seeding depth and tire type also demonstrated significance ($p = 0.033$). The probability of error for all tests was maintained at 0.05, and the grand mean of fuel consumption across treatments was 7.565 (l/ha).

Table 2 (ANOVA) of fuel consumption

Dependent Variable: Fuel Consumption						
Source	**Sum of Squares**	**df**	**Mean Square**	**F cal.**	**Sig.**	**F Table**
Replication	.005	3	.002	0.193	0.900 S	3.07
Speed	.036	1	.036	4.509	0.046 S	4.37
Depth	1.549	1	1.549	193.012	0.000 S	4.37
Seed Drills	18.265	1	18.265	2276.184	0.000 S	4.37
Speed * Depth	.035	1	.035	4.343	0.050 S	4.37
Speed * Seed Drills	.042	1	.042	5.240	0.033 S	4.37
Depth * Seed Drills	.006	1	.006	0.713	0.408 N. S	4.37
Speed * Depth * Seed Drills	.000	1	.000	0.042	0.839 N. S	4.37
Error	.169	21	.008			
Corrected Total	20.106	31				

Figure 3 illustrates the combined influence of the three experimental factors tire; type, seeding depth, and tractor forward speed on fuel consumption. Although the triple interaction was not statistically significant, clear differences were observed among the mean values of individual factors and two-way interactions. The highest fuel consumption occurred when the iron tire was used at a seeding depth of 4 cm and a tractor speed of 10 km/h. Conversely, the lowest fuel consumption was recorded when the pneumatic tire was used at a depth of 2 cm and a speed of 7 km/h. Fuel consumption decreased significantly from 8.152 (l/ha) to 6.536 (l/ha), representing a 19.92% reduction, when the tire type was changed from iron to pneumatic at a 2 cm depth and 7 km/h speed. Likewise, at a 2 cm depth and 10 km/h speed, fuel consumption was reduced from 8.075 (l/ha) to 6.616 (l/ha), a decrease of 17.56%. As shown in Figure 1, fuel consumption also declined at a 4 cm seeding depth, from 8.493 (l/ha) to 6.943 (l/ha) at 7 km/h, and from 8.560 (l/ha) to 7.142 (l/ha) at 10 km/h, when pneumatic tires were used instead of iron. In all treatments, a higher fuel consumption was recorded at 10 km/h, except for the iron tire at 2 cm depth, where fuel use slightly decreased from 8.152 (l/ha) to 8.075 (l/ha).

Overall, Figure 1 demonstrates that the tractor engine consumed less fuel when operating with pneumatic tires compared to iron tires. While tractor forward speed had a moderate effect on fuel consumption, increasing it from 7 to 10 km/h resulted in a slight rise in fuel use. In contrast, seeding depth exerted a stronger influence, with deeper seeding(4 cm) consistently leading to higher fuel consumption than shallower seeding (2 cm).

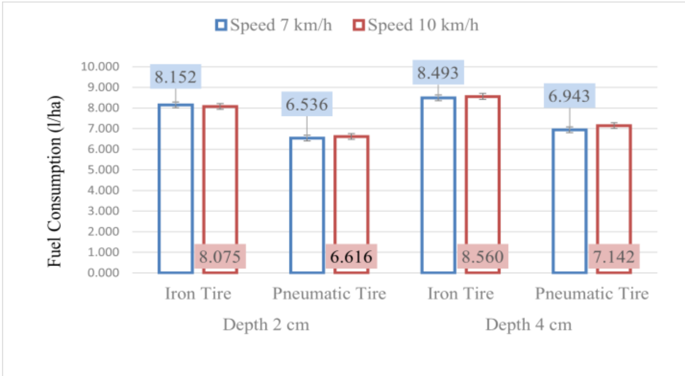

Figure 3 Effects of triple factors on consumed fuel (liter/hectare). 0.00588 is the means of standard error bars, (d.f) = 21, n = 3

According to the statistical analysis presented in Table 3, seeding depth (p = 0.000) and tire type (p = 0.000) exerted highly significant effects on the time requirement of the seeding operation. Moreover, the interaction between tractor forward speed and seeding depth (p = 0.008), as well as that between forward speed and tire type (p = 0.042), also demonstrated statistically significant influences. Conversely, forward speed alone, the interaction between seeding depth and tire type, and the combined three-way interaction among forward speed, seeding depth, and tire type did not yield significant effects on time requirement, as indicated by p-values of 0.560, 0.235, and 0.846, respectively. The overall mean time requirement across all experimental treatments was estimated at 0.316 h/ha, reflecting the average operational efficiency under the tested conditions.

Table 3 (ANOVA) of time requirement

Dependent Variable: Time Required						
Source	**Sum of Squares**	**d.f**	**Mean Square**	**F cal.**	**Sig.**	**F Table**
Replication	3.334E-5	3	1.111E-5	0.553	0.652 N. S	3.07
Speed	7.031E-6	1	7.031E-6	0.350	0.560 N. S	4.37
Depth	.001	1	.001	30.053	0.000 S	4.37
Tire Types	.033	1	.033	1640.568	0.000 S	4.37
Speed * Depth	.000	1	.000	8.749	0.008 S	4.37
Speed * Tire Types	9.453E-5	1	9.453E-5	4.705	0.042 S	4.37
Depth * Tire Types	3.003E-5	1	3.003E-5	1.495	0.235 N. S	4.37
Speed * Depth * Tire Types	7.813E-7	1	7.813E-7	0.039	0.846 N. S	4.37
Error	.000	21	2.009E-5			
Corrected Total	.034	31				

Figure 4 illustrates the effects of the three experimental factors on the time required to seed a unit area (h/ha). Significant differences were observed between the two tire types at a seeding depth of 2 cm across both levels of tractor forward speed. At 7 km/h and 10 km/h, the time required decreased from 0.343 to 0.274 h/ha and from 0.346 to 0.283 h/ha, respectively, when the iron tires were replaced with pneumatic tires. At the 4 cm seeding depth, the pneumatic tires also required less time than the iron tires at both forward speeds. The shortest operational time was recorded at a speed of 7 km/h and a depth of 2 cm with pneumatic tires, whereas the longest time was recorded at a speed of 10 km/h and a depth of 4 cm using iron tires. Conspicuously, there were no significant differences between the two forward speed levels at a 4 cm depth when pneumatic tires were used.

In conclusion, Figure 4 demonstrates that the seed drill equipped with pneumatic tires consistently required less operational time across both seeding depths and forward speeds compared to the iron tire configuration. Furthermore, the findings suggest that lower operational speeds (7 km/h) generally increased time requirements, regardless of tire type or seeding depth. In conclusion, figure 4 shows that the seed drill with a pneumatic tires at both levels of speed and depth of seeding is required a lower time compared to an iron tires. It also illustrates that much more time required if the seed drill be operated at 7 km/h.

The first hypothesis stated in the introduction was accepted, as the measured energy consumption significantly decreased when the pneumatic tire was utilized with the seed drill at both seeding depths and forward speeds independently. This finding aligns with the results reported by (Battiato & Diserens, 2017; Damanauskas *et al.*, 2015; Fanigliulo *et al.*, 2022; Hoy *et al.*, 2014), but contradicts the findings of (Ibrahim kareem & Sven, 2019). At a seeding depth of 2 cm and forward speeds of 7 km/h and 10 km/h, approximately three-quarters of the fuel was consumed when using pneumatic tires compared to iron tires. Conversely, at a seeding depth of 4 cm, the fuel consumption was about 20% lower for pneumatic tires than for iron tires across both speed levels. Hence, pneumatic tires demonstrated superior fuel economy and exerted a lower impact on variable inputs, particularly fuel consumption.

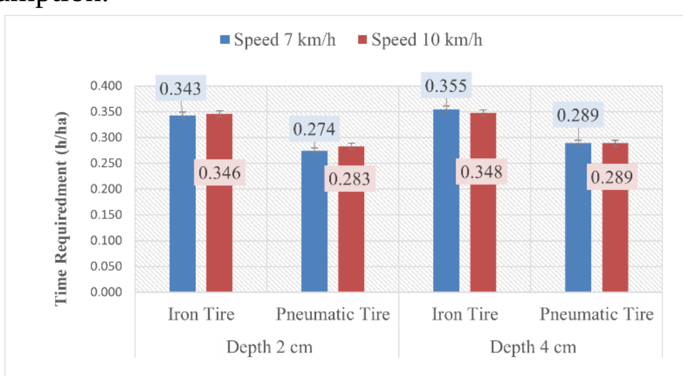

Figure 4 Effects of triple factors on time requirement (hour/hectare). 0.00588 is the means of standard error bars, (d.f) = 21, n = 3

The second hypothesis, in general, was rejected with respect to fuel consumption, as overall, lower fuel consumption was recorded for the tractor power unit at reduced forward speeds, except in the case of iron tires at a seeding depth of 2 cm. The fuel consumption values for iron tires at a 2 cm depth were 8.152 and 8.075 l/ha at 7 km/h and 10 km/h, respectively. These results are consistent with the findings of (Ibrahim kareem & Sven, 2019; Janulevičius *et al.*, 2019; KADHIM & IDHAS, 2017). Regarding the time requirement hypothesis, the degree of acceptance was approximately 50%, as both tire types required more operational time at a speed of 10 km/h than at 7 km/h at a seeding depth of 2 cm. This observation corresponds to the findings of (Damanauskas *et al.,* 2019; Fanigliulo *et al.*, 2022; Hoy *et al.*, 2014; KADHIM & IDHAS, 2017; Narendra *et al.*, 2014). Conversely, Less time was required with both types of tires at a 4 cm seeding depth at both movment levels which allies with the findings mentioned by (Fanigliulo *et al.,* 2022; Hoy *et al.,* 2014; Janulevičius *et al.,* 2019; KADHIM & IDHAS, 2017).
At both tractor speed levels with the use of both tire types, a significant difference was observed between the seeding depth levels in terms of fuel consumption, thus supporting the third hypothesis, which is regular with the results found by (Battiato & Diserens, (2017; Damanauskas *et al.,* (2015); KADHIM & IDHAS, (2017); Oduma *et al.,* (2022). On the other hand, these results contradict findings of (Ibrahim kareem & Sven, (2019), that indicated that the amount of fuel consumption decreased during deeper seeding. Therefore, it is better to seed at a depth of 2 cm compared to 4 cm to consume less amount of fuel.

CONCLUSION

The seeding operation can be affected by several parsmeters including tire types, seeding depths, and operating speed levels in terms of fuel consumption and time requirements. According to the findings of this study in general, when the pneumatic tires were attached to the seed drill at both speed and depth levels, the tractor engine used less fuel than the iron tires. More precisely, the lowest amount of fuel was consumed by the tractor engine when it seeded wheat at the speed of 2 km/h and at the depth of 2 cm by while the seed drill fitted with pneumatic tires. In conclusion, this study recommends the use of a seed drill equipped with pneumatic tires operating at a seeding depth of 2 cm and a forward speed of 7 km/h to achieve optimal performance in terms of fuel efficiency and operational time.

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