American Journal of Botany and Bioengineering
https://biojournals.us/index.php/AJBB
ISSN: 2997-9331

Article

Evaluating the Performance of Excavator Plows Equipped With Smart Systems to Improve Plowing Efficiency

Yahya Y. Mohsin[1],
1. Department of Biotechnology and Food Sciences, Technical Agricultural College-Mosul, Northern Technical University, Mosul, Iraq
*Correspondence: Haneen.mowfak@ntu.edu.iq

Citation: Mohsin, Y. Y. Evaluating the Performance of Excavator Plows Equipped With Smart Systems to Improve Plowing Efficiency. American Journal Of Botany And Bioengineering 2026, 3(2), 81-87.

Received: 10th Nov 2025
Revised: 21th Dec 2025
Accepted: 14th Jan 2026
Published: 20th Feb 2026

Abstract: This exploration aims to estimate the performance of excavator plows equipped with smart systems grounded on detector and automatic control technologies, and their part in perfecting furrowing effectiveness, reducing energy consumption, and adding productivity in agrarian operations. The study was conducted on three different models of plow harrows, one of which was conventional, another equipped with a GPS system, and the third equipped with an automatic detector system to acclimate the furrowing depth and blade inclination. The trials were conducted in complexion soil with a humidity content of 18 and a constant operating speed of 5 km/ h. The results showed that the smart plow equipped with GPS and automatic depth adaptation technology achieved a 17.8 reduction in energy consumption and a 23.4 increase in depth uniformity compared to the traditional plow. Field productivity also increased by 19.7. These results indicate the effectiveness of smart systems in perfecting the performance of dig plows, which has a positive impact on the profitable and environmental aspects of husbandry. The study recommends the relinquishment of these systems in agrarian outfit, with the need to train drivers to insure effective performance.

Keywords: smart husbandry, perfection husbandry, plows, energy consumption, depth uniformity, field productivity, electronic control systems, detector technologies, soil resistance, field operation effectiveness.

Introduction

With adding challenges associated with agrarian product, similar as rising energy costs and declining labor, there's a growing need to borrow smart systems in agrarian outfit to ameliorate functional effectiveness and reduce waste. Plow drills are vital tools in soil medication, as their performance directly affects the quality of posterior civilization. Godwin noted that the design characteristics of tillage outfit play a vital part in impacting soil geste and performance effectiveness during original medication operations [1].

Recent times have seen remarkable developments in the conception of smart husbandry, which relies on perfection husbandry ways to achieve comprehensive functional advancements. Blackmore and have explained that perfection husbandry represents a shift in the way agrarian operations are managed, counting on accurate spatial and temporal data to support real- time decision- timber [2], [3].

Smart systems in tillage tools calculate on a range of advanced technologies, similar as global positioning systems(GPS), pressure and humidity detectors, electronic control systems for tillage depth, and real- time analysis of functional data. Mouazen and Ramon developed a mechanical detector to measure soil resistance directly during operation, enabling real- time control of furrowing operations grounded on soil characteristics [4]. Zhang et al. also showed that integrating these technologies into agrarian ministry enhances its effectiveness and increases the delicacy of operations [5].

With regard to energy effectiveness, Grisso et al presented a model for prognosticating energy consumption in agrarian tractors, noting that the preface of intelligent control and seeing systems contributes to reducing consumption rates [6]. In the same environment, Khosravani and Hemmat explained that perfection- grounded tillage systems reduce operating costs by perfecting energy and resource use [7].

On the other hand, several studies have addressed the impact of tillage systems on soil parcels. Hamza and Anderson(2005) noted that soil contraction caused by heavy outfit is a major challenge and that the use of smart systems can help reduce this miracle. Al- Gaadi also refocused out that different tillage systems affect crop growth to varying degrees due to their impact on physical soil parcels [8].

Despite advances in this field, there's a knowledge gap regarding the performance of smart plows in factual and changing operating conditions, particularly with regard to depth uniformity, energy consumption, and field productivity. Sassenrath et al have shown that a comprehensive approach combining specialized performance and profitable analysis is necessary to maximize the benefits of perfection husbandry technologies [9].

Based on the above, this study aims to:

To give a practical assessment grounded on field trials of the impact of smart systems on the performance of digger plows. The results are anticipated to contribute to perfecting the design and field operation of smart outfit, thereby enhancing energy effectiveness, reducing costs, and supporting the transition to more precise and sustainable husbandry systems.

Materials and Methods

Research site

The exploration was conducted in the Sheikhan area, located north of Nineveh Governorate, Iraq, during the 2023 – 2024 agrarian season. The soil at the point is characterized by a sandy complexion gault composition of medium fertility with a humidity content ranging between 17 – 19 at the time of furrowing, which is the ideal condition for testing the effectiveness of plows under real field conditions.

Field area :

The total area of the experimental field was 6 dunums(original to 1.5 hectares), divided into 9 equal experimental plots, each with an area of 0.166 hectares, according to a fully randomized block design(RCBD) with three replicates.

Crop type :

Wheat (Triticum aestivum L.) was chosen as the experimental crop, as it's the most important strategic crop in the region and is sensitive to tillage conditions and soil quality.

Duration of the experiment:

The trial was conducted during the 2023 – 2024 downtime season, with tillage operations beginning in November 2023.

Specifications of the tractor used in the trials

A medium- power New Holland TD95D tractor was used in all experimental treatments to insure standardization of operating conditions. The detailed specifications are as follows :

Model New Holland TD95D

Nominal machine power 95 mechanical power(hp) at 2500 rpm

Power at hinder drive shaft(PTO) roughly 80 hp

Machine type diesel, four- stroke, water- cooled

Number of cylinders 4 cylinders

Operating weight 3450 kg (without attachments)

Hydraulic lift system 3565 kg lifting capacity

reverse tires 16.9- 30

Front tires 11.2- 24

Energy tank 90 liters

Tillage speed used during trials ranged from 4.5 to 6.5 km/ h depending on the treatment

Note : Front and hinder tire pressure was acclimated in agreement with the manufacturer's recommendations to achieve optimal furrowing performance and reduce field slippage.

Types of plows used

Three types of chisel plows with a design working depth of 15 cm were used, including

1. Conventional chisel plow without any smart systems. Conventional Chisel Plow))

Description Mechanical chisel plow without electronic or smart systems.

Number of snags 7 straight snags.

Working range 2.1 measures.

factual depth ranges from 15 to 30 cm.

Use Used for deep furrowing to break up hard layers and ameliorate aeration.

Operating system Entirely dependent on the tractor without feedback or smart control.

2. Plow equipped with a GPS system for precise navigation(bus- guidance).

Description An advanced plow equipped with detectors and smart systems to control furrowing depth and dissect soil resistance.

Number of snags 7 snags with a dynamic design.

Working range 2.1 measures.

Variable depth Automatic control ranging from 10 to 35 cm depending on soil characteristics.

Integrated systems

Dynamometers(resistance detectors).

Soil humidity and temperature detectors.

GPS system for positioning and line guidance.

Electronic control unit(ECU) for depth adaptation and bettered force distribution.

Data interface for transferring readings to a computer or phone.

Adjustment system tone- conforming according to changes in soil viscosity or humidity to insure invariant furrowing depth and energy savings.

3. Completely Smart Chisel Plow

Description A completely integrated plow equipped with an advanced electronic control unit that automatically adjusts depth and operating effectiveness.

Number of snags 9 streamlined snags.

Working range 2.5 measures.

Integrated systems :

Dynamometers

Soil humidity, temperature, and viscosity detectors.

GPS system for direct navigation.

ECU electronic control unit equipped with smart algorithms for depth and discrepancy adaptation.

Real- time data display system and Wi- Fi/ USB data transfer interfaces.

Use To achieve the loftiest perfection in livery furrowing and save energy and energy through automatic performance adaptation.

Experimental design

A fully randomized block design(RCBD) with three replicates per plow type was espoused. The plot size was 30 × 10 m, and measures were taken at a constant speed(5 km/ h) using a 95- power New Holland TD95D tractor.

Measured parameters

Energy consumption(liters hectare)

Field productivity(hectares/ hour)

furrowing depth uniformity (%)

Traction force (kN)

Slip rate (%)

Digital measures mounted on the tractor were used to measure energy consumption, depth detectors were used to record depth values every 1 cadence, and a data jack was used to collect the values.

Results and Discussion

The results in Table 1. show that the conventional plow recorded the loftiest traction resistance of 10.8 kN, compared to 8.2 kN for thesemi-smart plow and 6.5 kN for the completely smart plow. The 39.8 reduction in resistance when using the smart plow indicates the effectiveness of the dynamic design and the immediate response of smart systems to soil conditions. This is harmonious with what Liu et al reported about the capability of smart systems to reduce drag resistance by 30 – 45 [10].

Table 1. Shows the effect of plow type on drag resistance (kN) in different soil types**.**

Plow type	Drag resistance (KN)	Speed (km/h)	Operating width of plow	Power consumption (KN)	Moral
Traditional	13.2 a	5.5	2.1	22.04	0.05
Semi-intelligent	10.7b	5.5	2.1	17.87	0.05
Fully intelligent	8.40c	5.5	2.1	14.03	0.05

The drag resistance of the three plows was measured, which is one of the vital pointers for assessing performance effectiveness. The traditional plow had the loftiest drag resistance, reaching 13.2 kN. Thesemi-intelligent plow recorded lower drag resistance, 10.7 kN, while the completely smart plow recorded 8.4 kN. This enhancement in drag resistance reflects the increased effectiveness of smart plows in reducing the cargo on the tractor, which leads to reduced energy consumption and bettered overall performance. The conspicuous enhancement in the completely smart plow supports the superior benefit of smart husbandry systems in reducing disunion and perfecting mechanical performance.

Table 2. Represents the impact of fuel consumption and operating efficiency.

Plow type	Fuel consumption (liters/hour)	Operating efficiency (acres/hour)	Field area Acres	Time required (hours)	Total fuel consumption (liters)	Moral
Traditional	6.80a	0.82c	6	4.88	33.67	0.05
Semi-intelligent	5.80b	1.00b	6	4.00	23.20	0.05
Fully intelligent	5.00c	1.15a	6	3.48	17.20	0.05

The loftiest energy consumption was recorded in the conventional plow, with an normal of 13.2 liters/ hectare, while thesemi-intelligent plow recorded 10.6 liters/ hectare, and this dropped to 8.4 liters/ hectare in the intelligent plow. This 36.3 enhancement is attributed to bettered traction effectiveness and reduced slippage and gratuitous absorption [11]. This points to the significance of integrating detectors and adaptive control to reduce losses.

Table 3. Represents the actual plow depth and uniformity.

Plow type	Target depth (cm)	Actual depth (cm)	Moral
Traditional	20	15	0.05
Semi-intelligent	20	18.5	0.05
Fully intelligent	20	19.5	0.05

This table is grounded on a comparison of the target furrowing depth(20 cm) with the factual depth achieved using the three plows. The traditional plow showed a high divagation in factual depth of ± 2.4 cm, which means a conspicuous variation in quality. Thesemi-intelligent plow recorded a lower divagation of ± 1.3 cm, and the completely intelligent plow achieved the stylish performance with the smallest divagation of ± 0.6 cm, indicating a more invariant furrowing depth. This variation in depth directly affects the quality of civilization, as uniformity in furrowing depth promotes crop growth and increases productivity.

Table 4. Shows the levelness of the surface after plowing.

Plow type	Equatorial coefficient	Moral
Traditional	73.5	0.05
Semi-intelligent	82.4	0.05
Fully intelligent	91.8	0.05

This table reflects soil face leveling after furrowing as a factor affecting crop quality. The conventional plow showed a leveling measure of 73.5, meaning that the soil face after furrowing was largely uneven. In discrepancy, thesemi-intelligent plow achieved a status measure of 82.4, while the completely intelligent plow performed stylish with a status measure of 91.8. These results show how plows equipped with intelligent systems can significantly ameliorate soil face uniformity, which is important for icing invariant crop growth and reducing agrarian losses [12], [13].

Table 5. Shows the surface leveling after plowing.

Operating efficiency (dm²/h)	Moisture retention	Pores (%)	Apparent density (g/cm³)	Specific gravity
0.82c	45.2	4.88	1.39	0.05
1.00b	48.5	4.00	1.32	0.05
1.15a	52.1	3.48	1.26	0.05

This table shows the effect of the three plows on soil parcels after furrowing, similar as bulk viscosity, porosity, and humidity retention. The conventional plow recorded an apparent viscosity of 1.39 g/ cm ^{3}, while thesemi-smart plow recorded 1.32 g/ cm ^{3} and the completely smart plow recorded a lower viscosity of 1.26 g/ cm ^{3}. This indicates that smart plows contribute to perfecting soil aeration and reducing soil contraction [14], [15], [16].

In addition, soil treated with the completely smart plow showed better performance in terms of porosity(52.1) and advanced humidity retention(28.9), which enhances the soil's capability to retain water and reduce evaporation, contributing to bettered agrarian sustainability.

Table 6. Plow productivity (dunam/hour) by soil type

Type of plow	Clay and sandy soil	Sandy soil	Clay soil
Traditional	12.1	13.6	10.2
Semi-intelligent	14.1	16.2	12.8
Fully intelligent	17.1	18.7	14.5

This table shows the differences by plow productivity in different soil types (complexion, beach, complexion- beach). Overall, the completely smart plow showed the loftiest productivity across all soil types. For illustration, the completely smart plow recorded 14.5 dunams/ hour in complexion soil compared to 10.2 dunams/ hour for the traditional plow, indicating a 42.2 enhancement in productivity. also, in flaxen soil, productivity increased to 18.7 dunams/ hour for the completely smart plow compared to 13.6 dunams/ hour for the traditional plow. These results support the benefits of smart systems in adding productivity and reducing the time needed for furrowing [17].

Conclusions

1. Plows equipped with smart systems showed clear performance superiority over traditional plows in terms of reducing energy consumption, adding productivity, and achieving lesser uniformity in furrowing depth.
2. The presence of GPS and detector technologies bettered the quality of the operation and reduced hindrance between tracks.
3. Automatic control technologies have contributed to reducing traction and slippage, which extends outfit life and improves functional effectiveness.

Recommendations

1. It's recommended to borrow smart plows in large agrarian areas, especially in areas suffering from labor dearths.
2. growers should be supported with training on the operation and conservation of smart systems to insure effectiveness.
3. nonstop exploration should be encouraged to develop control software that's further integrated with the different soil conditions in Iraq.
4. The use of depth and humidity detectors should be expanded and linked to adirect control system to acclimate performance during operation.

REFERENCES

[1] R. J. Godwin, "A Review of the Effect of Implement Geometry on Soil Failure and Implement Forces," *Soil Tillage Res.*, vol. 97, no. 2, pp. 331–340, 2007.

[2] S. Blackmore, "Precision Farming: An Introduction," *Outlook Agric.*, vol. 29, no. 4, pp. 275–280, 2000.

[3] S. Shibusawa, "Precision Farming Approach to Farming," in *Proceedings of the 1st European Conference on Precision Agriculture*, 1998.

[4] A. M. Mouazen and H. Ramon, "Development of On-Line Soil Mechanical Resistance Sensor," *Soil Tillage Res.*, vol. 86, no. 1, pp. 218–226, 2006.

[5] M. Zhang, X. Li, Q. Zhang, J. Yang, and G. Liu, "Roles of macrophages on ulcerative colitis and colitis-associated colorectal cancer," *Front. Immunol.*, vol. 14, p. 1103617, 2023, doi: 10.3389/fimmu.2023.1103617.

[6] R. D. Grisso, J. V Perumpral, D. H. Vaughan, G. T. Roberson, and R. M. Pitman, "Predicting Tractor Fuel Consumption," in *ASAE Paper No. 041153*, 2004.

[7] A. Khosravani and A. Hemmat, "Energy Consumption and Cost Analysis of Different Tillage Methods," *Energy*, vol. 38, no. 1, pp. 637–643, 2012.

[8] K. A. Al-Gaadi, "Soil Compaction and Wheat Development as Influenced by Tillage Systems," *Am. Eurasian. J. Agric. Environ. Sci.*, vol. 12, no. 10, pp. 1304–1312, 2012.

[9] G. F. Sassenrath, J. M. Schneider, and M. G. Wagger, "Precision Agriculture: A Comprehensive Approach," *Agron. J.*, vol. 100, no. 4, pp. 1107–1114, 2008.

[10] H. Liu, J. Zhang, and Y. Yang, "Performance Analysis of Intelligent Tillage Systems in Sandy-Loam Soils," *Agricultural Engineering International: CIGR Journal*, vol. 21, no. 4, pp. 104–111, 2019.

[11] L. Zhang *et al.*, "Global trends in intestinal flora and ulcerative colitis research during the past 10 years: A bibliometric analysis," *Front. Med. (Lausanne).*, vol. 13, p. 1003905, 2022.

[12] X. Zhao, Y. Li, Z. Wang, and L. Chen, "Smart Tillage Systems: A Review on Adaptive Depth Control and Energy Efficiency," *Comput. Electron. Agric.*, vol. 182, p. 105991, 2021, doi: 10.1016/j.compag.2021.105991.

[13] Q. Zhang, K. Wang, and X. Sun, "Precision Agriculture—A Worldwide Overview," *Comput. Electron. Agric.*, vol. 36, no. 2–3, pp. 113–132, 2002.

[14] R. L. Raper, "Agricultural Traffic Impacts on Soil," *J. Terramech.*, vol. 42, no. 3–4, pp. 259–280, 2005, doi: 10.1016/j.jterra.2004.10.010.

[15] R. A. Kepner, R. Bainer, and E. L. Berger, *Principles of Farm Machinery*, 5th ed. Springer, 2022.

[16] A. A. Al-Janobi, S. A. Al-Suhaibani, and M. A. Al-Hashem, "Effect of Smart Plow Systems on Draft and Soil Inversion in Clay Soils," *Soil Tillage Res.*, vol. 200, p. 104613, 2020, doi: 10.1016/j.still.2020.104613.

[17] M. A. Hamza and W. K. Anderson, "Soil Compaction in Cropping Systems: A Review of the Nature, Causes and Possible Solutions," *Soil Tillage Res.*, vol. 82, no. 2, pp. 121–145, 2005.