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The Impact of Tractor Speed and Additional Weights on the Total Costs and Some Performance Indicators of the Gardener's Tractor

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ABSTRACT

A field experiment was executed to assess the performance of the New Holland **1520**gardener tractor for plowing and smoothing operations by analyzing total costs, pulling force (kN), drawbar power and slippage percentage at varying operational speeds and added weights. The primary element, speed, was established at three levels (2.58, 4.50, 6.48 km/h) for the plowing process and (2.62, 4.67, 6.69 km/h) for the smoothing process, while the secondary factor comprised additional weights (60, 90, 120 kg). The plowing process findings indicated that a speed of 6.48 km/h yielded the lowest total costs of 10,937.6 ID/hectare, alongside the highest pulling force of 4.20 kN and the maximum drawbar power of 7.55 kW. Increasing the added weights from 60 kg to 90 kg and subsequently to 120 kg resulted in a reduction in overall expenditures from 20507.1 to 19652.2 to 18607.2 ID / hectare. A reduction in pulling force values from 4.13 to 3.93, subsequently to 3.69 kN; a decline in drawbar power from 5.16 to 5.04, then to 4.83 kW; and a fall in slippage percentage from 11.95 to 10.34, followed by 8.81%. The smoothing process yielded the lowest total costs of 9664.2 ID/hectare at a speed of 6.69 km/h. The maximum pulling force attained was 2.64 kN, while the peak drawbar power reached 4.90 kW.The increment of weights from 60 to 90 to 120 kg resulted in a reduction of total costs from 18757.9 to 17242.1 to 16472.1 ID/hectare, a decline in drawbar power values from 2.69 to 2.47 to 2.22 kN, a decrease in drawbar power from 3.48 to 3.26 to 3.02 kW, and a reduction in slippage percentage from 9.34 to 8.03 to 6.30%.

تأثير سرعة الجرار والأوزان الإضافية على التكاليف الكلية وبعض مؤشرات الأداء للجرار البستاني

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الخلاصة

تم إجراء التجربة الميدانية لتقييم أداء الجرار البستاني (New Holland T1520) في عملية الحراثة بأستخدام المحراث مطرحي ذو البدنين وفي عملية التنعيم بأستخدام المحراث الدوراني وذلك من خلال دراسة كل من التكاليف الإجمالية ، قوة السحب،قدرة السحب و نسبة الانزلاق المئوية . تم اختيار السرعة (العامل الأساسي) على ثلاثة مستويات (2.58، 4.50، 6.48 كم/ساعة) لعملية الحراثة و(2.62، 4.67، 6.69 كم/ساعة) لعملية التنعيم ، بينما كان العامل الثانوي يتضمن أوزانًا إضافية (60، 90، 120 كغم) حيث ابانت النتائج في عملية الحراثة : ان السرعة 6.48 كم/ ساعة تفوقت في الحصول على أقل تكاليف اجمالية وبلغت 10937.6 دينار/ هكتار وأعلى قيمة في قوة السحب وبلغت 4.20 كيلو نيوتن وأعلى قيمة في قدرة السحب وبلغت 7.55 كيلو واط . أدت زيادة الاوزان من 60 إلى 90 إلى 120 كغم إلى انخفاض في التكاليف الاجمالية من 20507.1 الى 19652.2 إلى 18607.2 دينار / هكتار وانخفاض في قيم قوة السحب من 4.13 إلى 3.93 ثم إلى 3.69 كيلو نيوتن وانخفاض في قدرة السحب من 5.16 إلى 5.04 ثم إلى 4.83 كيلو واط وانخفاض في نسبة الانزلاق من 11.95 الى 10.34 ثم إلى 8.81 %،اما في عملية التنعيم تفوقت السرعة 6.69 كم /ساعة في الحصول على أقل تكاليف اجمالية وبلغت 9664.2 دينار/ هكتار وأعلى قيمة في قوة السحب وبلغت 2.64 كيلو نيوتن وأعلى قيمة في قدرة سحب وبلغت 4.90 كيلو واط . وأدت زيادة الاوزان من 60 إلى 90 إلى 120 كغم إلى انخفاض في التكاليف الإجمالية من 18757.9 إلى 17242.1 إلى 16472.1 دينار/ هكتار وانخفاض في قيم قوة السحب من 2.69 إلى 2.47 ثم إلى 2.22 كيلو نيوتن وانخفاض في قدرة السحب من 3.48 إلى 3.26 ثم إلى 3.02 كيلو واط وانخفاض في نسبة الانزلاق من 9.34 إلى 8.03 ثم إلى 6.30 %.

الكلمات المفتاحية: قوة السحب، نسبة الانزلاق، قدرة السحب

INTRODUCTION

The agricultural tractor is considered the backbone of production operations in the agricultural sector, as the success of modern agriculture depends on the efficiency of the tractor's performance, which occupies a vital position in operating various machines and equipment. Elashry and Youssef (2024) confirmed that the agricultural tractor forms the foundation of all production operations, necessitating the selection of the appropriate tractor and the precise evaluation of its performance. In this context, Aday (2016) points out that the selection of the tractor should not be done randomly, but rather based on criteria that align with the nature of agricultural work and soil requirements. On the other hand, reducing the costs of the agricultural process is a fundamental goal for any integrated project; Hamid and Alsabbagh (2024) explained that the biggest challenge lies in achieving a successful agricultural process with optimal efficiency for both tractors and the associated machinery, while reducing energy consumption and operational losses. In the same context, Alkaabi et al.(2022) emphasized the importance of calculating energy requirements and selecting agricultural tools that match soil characteristics and operating conditions, which contributes to maintaining the machine's lifespan and achieving performance sustainability. On the economic front, recent studies such as Mahore (2022) and Alkhafaji et al. (2018) have indicated that reducing overall costs whether in terms of purchase, operation, or maintenance requires the use of highly efficient agricultural machinery.

Technical performance indicators such as pull, slippage percentage , and the tractor's ability to operate rear axles are among the main indicators evaluated to determine the efficiency of agricultural tractors (Al-Azzawi et al.,2022 ; Mhaibis and Salim, 2023).Previous studies have addressed the impact of various operational variables on tractor performance. Al-Janobi et al. (2020) explained that drawbar pull is considered one of the most important factors affecting the suitability of tractors for plowing operations. Their study showed that using a reversible moldboard plow resulted in pull force values ranging between 1.27 and 2.49 kN and drawbar power between 3.15 and 6.95 kW, reflecting the impact of soil texture, plowing depth, and speed. Mankhi (2012) found that increasing the operational speed of the tractor from 2.45 to 6.65 km/h led to an increase in pull force from 6.56 to 7.73 kN, confirming the positive relationship between tractor speed and its performance efficiency. Other research indicated that the interplay between velocity and additional weights enhances technical performance. Kadhim and Subr, (2012) determined that elevating the speed from 3.21 to 7.04 km/h resulted in enhanced pulling power and reduced fuel usage. The study results suggested that the addition of rear weights led to an increase in slippage percentage while enhancing pulling power and fuel efficiency. Amer (2017) noted that operational speed and plow type markedly affected slippage percentage , with higher speeds associated with increasing slippage percentage due to the greater strain on the plow resulting from raised cutting speeds.Conversely, prior research has demonstrated that incorporating weights onto tractor wheels can enhance tire grip with the soil and diminish the slippage percentage Grisso et al. (2007) shown that augmenting the weight on the rear wheels diminishes slippage percentage , as evidenced by an increase in weight from 2.27 to 3.14 kg, which corresponded to a drop in slippage percentage from 19% to 15%. Aday et al. (2002) discovered that incorporating weights between 10-30% of the total tire weight enhances the tractor's pulling capacity, hence augmenting operating efficiency Jasim and Mhaibis (2016). L

lustrated that augmenting the load on the attached machine enhances its pulling capacity, underscoring the significance of examining the correlation between extra weights and speed. From an economic perspective, Hamid (2013) The escalation in plowing speed from 1.85 to 3.75 and subsequently to 5.62 km\h resulted in a reduction of total plowing costs from 21,152 to 10,572 and then to 7,207 dinars per hectare, reflecting respective decreases of 50.01% and 31.82%. The improvement in plowing speed led to enhanced operational productivity, thereby lowering total costs, indicating an inverse link between costs and operational productivity. Nevertheless, a study of the literature indicates that the majority of research have concentrated on analyzing the effects of individual operational variables (such as speed or weight) in isolation, without investigating the intricate interactions among them. Despite advancements in comprehending the influence of speed and engineering parameters on drawbar pull, a research gap persists regarding the examination of how weight distribution, alongside other operational factors such as speed and soil conditions, impacts the technical and economic performance of tractors. Zhang et al.(2021) underscore the imperative to implement an integrated model that accounts for the effects of fluctuating field conditions and various operational variables to enhance the precision of tractor performance evaluation. They stress the necessity of undertaking thorough research that amalgamates technical analysis with economic assessment to facilitate informed decision-making in tractor selection and the application of performance enhancement strategies.

Given the importance of choosing the appropriate forward speed and the weight added to the tractor for the purpose of obtaining the most effective indications of the performance of the mechanical unit, this study conducted to control these two factors and study the relationship between them and measure the technical indicators (total costs, drawbar power, slippage percentage) of the mechanized unit in two different agricultural operations (plowing, Smoothing). Therefore, the aim of the research includes evaluation of the performance of a Gardener tractor (New Holland T1520) in the process of tillage with Two-Bottom Moldboard Plow and in the process of Smoothing with a rotary plow under the influence of different speeds and additional weights, and Finding the optimal amalgamation between the forward speed and the added weights of the tractor to give to attain optimal operational and economic compatibility that guarantees maximum efficiency in tractor utilization while preserving machine sustainability and soil integrity.

Materials and methods

The study comprised two factors. The first factor is the forward speed of the tractor, evaluated at three levels: 2.58, 4.50, and 6.48 km/h for the tillage process, and 2.62, 4.67, and 6.69 km/h for the smoothing process. The second factor involves the added weights for the gardener tractor, assessed at three levels: 60 kg, 90 kg, and 120 kg.The initial tractor utilized was the New Holland T1520 gardener tractor seen in Figure 1 with specifications specified in Table 1, equipped with to the moldboard plow depicted in Figure 2, with specifications specified in Table2, during the plowing and with a rotary plow illustrated in Figure 3, with specifications detailed in Table 3, during the smoothing operation. The second tractor was a New Holland 80_66S, featuring an 80-horsepower engine and of Turkish origin. The operating depth was set to 15 cm for the plowing process and 10 cm for the smoothing process. A randomized complete block design was employed, and the results underwent statistical analysis. Significant differences were assessed using the least significant difference (LSD) method at a probability level of 0.05. The experimental unit measured 20 meters in length, with a distance of 15m maintained prior to each replication to ensure the tractor achieved a constant speed. The treatments were allocated randomly within the replication.

Figure 1 illustrates the New Holland T1520 tractor.

Table 1 shows the technical specifications of the New Holland T1520 tractor.

Feature	Specification
Engine Power	35 HP @ 2000 RPM
Engine Type	4-cylinder diesel
Transmission	9 Forward / 3 Reverse (Mechanical Gear)
Drive System	4WD
Hydraulic Lift Capacity	Approx. 650 kg (3-point hitch)
Total Weight	Approx. 1089 kg (without ballast)

Figure 2 illustrates the moldboard plow.

Table 2 shows the technical specifications of the moldboard plow.

Model	**Italia**
Number of bodies	2
Width moldboard	63 cm
Distance between the weapon	70 cm
Width weapon	32 cm
Manufacturing year	2010
Company	Nardi
Style	Bp18g

Figure 3 illustrates the rotary plow

Table 2 shows the technical specifications of the rotary plow

Specification	**Details**
Manufacturer	WOONGJIN
Model	WJ140CM
Country of Origin	South Korea
Working Width	140 cm
Required Horsepower	More than 30 HP
Year of Manufacture	2006
Plowing Depth	10 cm

The measuring devices used in the experiment

Dynamometer for measuring pulling force

A Dillon-type mechanical spring dynamometer, of English origin and with a capacity of 20 kN, was employed to measure the pulling force of the mechanical unit

Fuel Consumption Meter

The exact fuel consumption is quantified utilizing a 500 ml graduated transparent cylinder linked to the tractor's fuel tank, which is replenished to capacity at the conclusion of each transaction. Initially, the valve linked to the cylinder is opened, while the valve associated with the tractor's primary fuel tank remains closed. Upon reaching the transaction's conclusion, the valve linked to the cylinder is closed, and the valve associated with the tank is opened. The fuel consumption is quantified by the markings on the cylinder, and this procedure is replicated for all transactions in the experiment.

Studied traits:

1- Total costs:

The total costs were measured according to the equations Al-Aani (2020) :

$D = \frac{P-S}{L}$….[Eq. 1]

D:Depeciation

P:price of tractor

S: Selling price

L: Service life

$\boldsymbol{Int} = \left(\frac{\frac{P+S}{2}}{L}\right) \times \mathbf{0.1}$….[Eq. 2]

Int: Interest costs

L: Number of operation hours per year

$\boldsymbol{Ist} = \left(\frac{P}{L}\right) \times \mathbf{2}\%$….[Eq. 3]

Ist: Insurance and shelter and taxes

$\boldsymbol{TOC = FC + VC + OHC}$….[Eq. 4]

TOC: Total operating costs of the tractor dinars/hour

Fc: fixed costs

Vc:Variable costs

OHC: administrative costs

$\boldsymbol{FC = D + Int + Ist}$….[Eq. 5]

FC : fixed costs dinars/hour

D : Annual consumption dinars/hour

Int: interest on capital

Ist Taxes, Insurance and Shelter

$\mathbf{Vc = Fu.c + Oc + MR + LC}$ …..[Eq. 6]

VC: Variable costs (ID)

Fu.c: Fuel costs (ID)

Oc: Oil costs (ID)

MR: Maintenance and repair costs (ID)

LC: Labor costs

$\mathbf{OHC} = (\mathbf{FC} + \mathbf{VC}) \times \mathbf{10}\%$….[Eq.6]

OHC: Administrative costs

FC fixed costs [ID]

VC: Variable costs [ID]

2 - Pulling force (KN) :

The plow was connected to the second tractor, the belt of the two tractors, and a dynamometer between them, and the plow was nearly in contact with the ground, in order to calculate the rolling resistance force (Frr).

Measuring the thrust and the plow during the tillage process (Fpu) by running the two tractorsand the dynamometer between them.

The pulling force was measured according to the following equation and suggested by (Elashry , 2010)

$\boldsymbol{Ft = Fpu - Frr}$ [Eq. 8]

Ft : Traction force (kN)

Fpu: total thrust and plow force during the tillage process ([kN)

Frr: The force of rolling resistance and the plow is almost touching the ground (kN)

3- drawbar power (KW):

The drawbar power was calculated using the following equation (Elashry , 2010)

$\mathbf{Pft} = \frac{\mathbf{Ft \times VP}}{\mathbf{3.6}}$…..……….[Eq.9]

Pft : drawbar power (kw)

Ft : Traction force(kN)

Vp: working speed (km/h)

4- Slippage percentage (%):

It is measured using the equation (Younis and Elashry, 2009):

$\mathbf{SP} = \frac{\mathbf{Vt - Vp}}{\mathbf{Vt}} \times \mathbf{100}$…..[Eq.10]

SP: slip rate

Vt: theoretical speed in the absence of load (km/hr).

Vp: Operational velocity under load (km/hr)

RESULTS AND DISCUSSION

Figure (4) illustrates the impact of tractor speed, additional weights, the nature of field operations, and their relationships on the overall cost of the gardener tractor ID/hectare utilizing a moldboard plow. The notable impact of tractor speed on the overall costs of the gardener tractor is observed , as the acceleration from 2.58 to 4.50 and subsequently to 6.48 km/hr with the moldboard plow resulted in a reduction of total costs from 32162.9 to 15666.0 and then to 10973.6 ID/hectare. The rationale for this may stem from the correlation between heightened speed and enhanced practical production, resulting in a reduction of total operating expenses. These findings align with those obtained in (Najim and Salim ,2024).

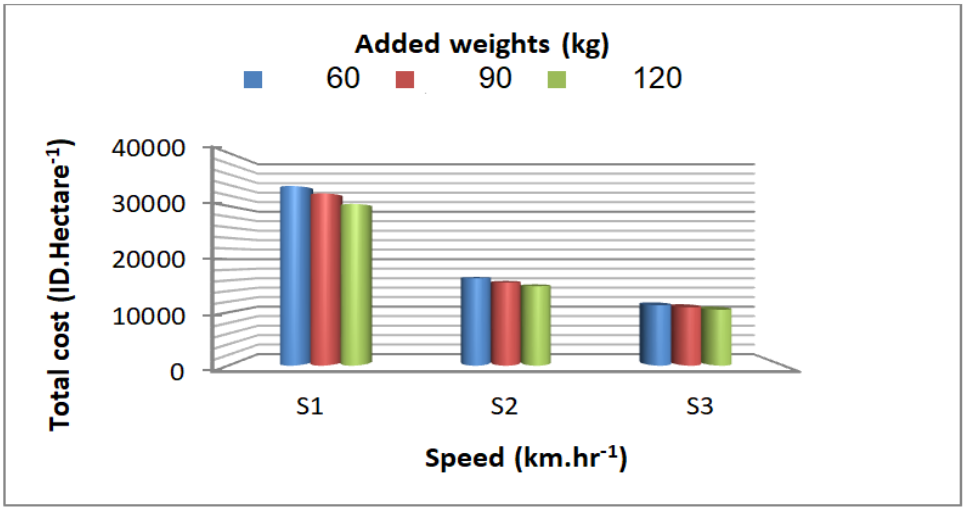

Figure 4 Effect of tractor speed and adding weight in total cost for the moldboard plow

It is clear from the same figure the effect of the impact of the additional weights on the rear axle of the tractor on the total cost of the mechanical unit, if when the weights increased from 60 to 90 and then to 120 kg it resulted in a reduction of total costs. from 20507.1 to 19652.2 and then to 18607.2 ID/hectare. The reason may be that adding weights leads to improving and increasing the area of cohesion between the wheels and the surface of the soil, which leads to reduced wheel slippage and thus increased productivity, resulting in a decrease in total costs (Al-Aani,2024). The interaction between a speed of 6.48 km/h and a weight of 120 kg excelled in achieving the lowest total costs, amounting to 10609.3ID/hectare. Figure (5) Shows the impact of tractor speed and additional weights, as well as their relationships, on the total cost of the gardener tractor (ID/ hectare) utilizing the rotary plow. The notable impact of the tractor's speed on the total costs of the gardener tractor is observed, as the increase in speed from 2.62 to 4.67 and then to 6.69 km/hr led to a decrease in the total costs of the gardener tractor from 28868.9 to 13939.0 and then to 9664.2 ID/hectare. The rationale for this may result from the correlation between heightened speed and enhanced practical production, resulting in a reduction of total operating costs (Hamid, 2024). It is clear from Figure (5) The impact of the additional weights on the tractor's rear axle on the total cost of the mechanical component during the operation of the rotary plow. When the weights were increased from 60 to 90 and then to 120 kg, it resulted in a reduction of total costs from 18757.9 to 17242.1 and then to 16472.1 ID/hectare.The interaction between a speed of 6.69 km/hr and a weight of 120 kg achieved the lowest total costs, amounting to 9058.2 ID/hectare.

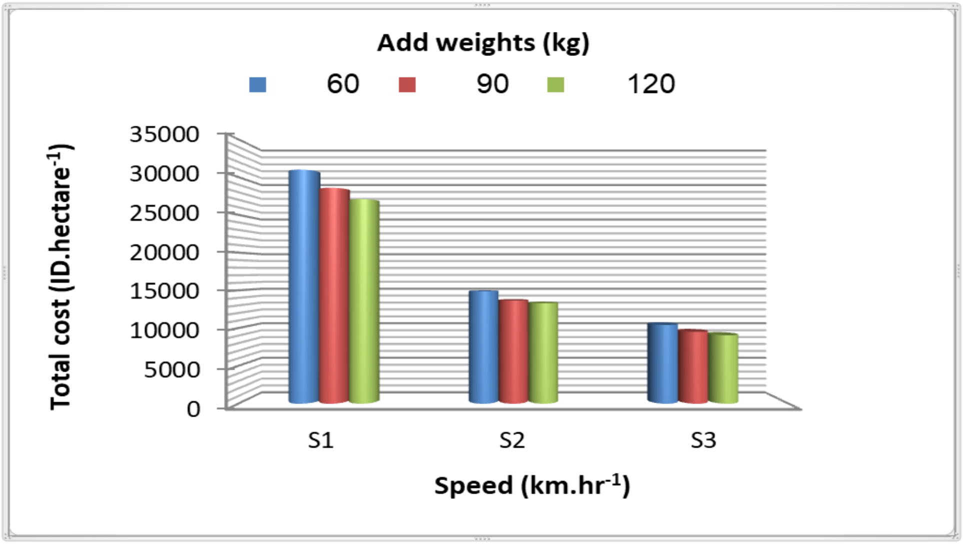

Figure 5 Effect of tractor speed and add weight in total cost for the rotary plow

The reason may be that the addition of weights leads to an improvement and increase of cohesion between the wheels and the soil surface due to the increase in the contact area between them, which leads to reduced wheel slippage and thus increased productivity, which led to a reduction in total costs. Figure (6) shows the influence of tractor speed and additional weights, together with their interactions, on the pulling force using a two-bottom moldboard plow is illustrated. The notable impact of tractor speed on draw force is observed, with an increase in forward speed from 2.58 to 4.50 and subsequently to 6.48 km/h leading to a marginal rise in pull force from 3.66 to 3.89 and finally to 4.20 kN. The velocity of 6.48 km/h had a peak value of 4.20 kN, whereas the velocity of 2.58 km/h reached a minimum value of 3.66 kN. The increased load on the plow may necessitate more acceleration of soil particles during displacement at higher speeds, resulting in increased resistance and, consequently, a greater draw force necessary for operation (Aday,2019; Shafaei *et al*.,2020 ; Balsari *et al*, 2021 ; Abdullah and Abdul Rahman, 2019)

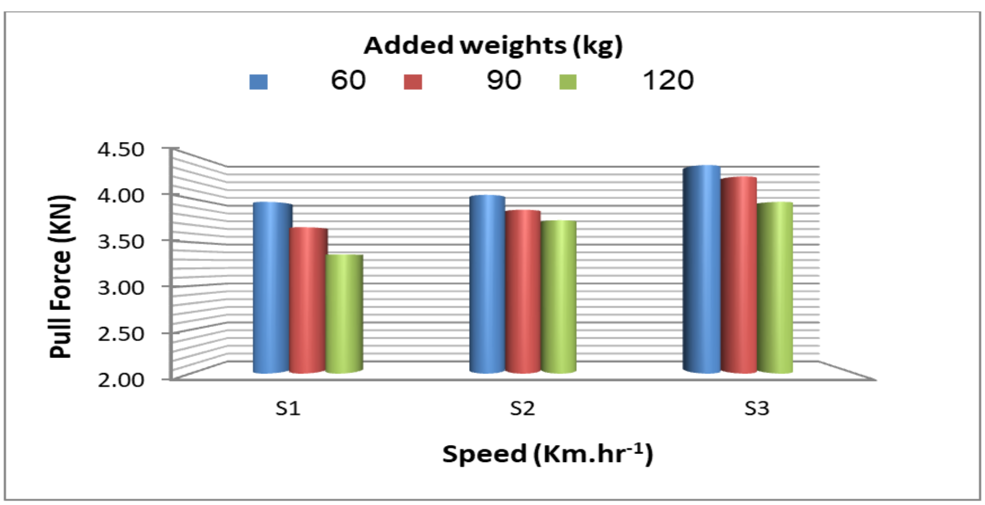

Figure 6 Effect of tractor speed and adding weight in pulling force for the moldboard plow

It is clear from the figure the significant impact of adding weights onto the tractor on the pulling force with the moldboard plow is demonstrated. As the weights were elevated from 60 to 90 kg and subsequently to 120 kg, the pulling force diminished from 4.13 to 3.93 and then to 3.69 KN, respectively. This reduction may be ascribed to the fact that augmenting the weights enhances the contact area of the wheels with the ground (Ramadhan et al., 2025). hence diminishing the necessary pulling force. The pulling force is affected by both the contact area and the weight on normal soils characterized by adhesion and friction (Hamid, (2024). Figure (7) shows the impact of forward velocities and additional weights on the rotary plow during the smoothing operation with the gardening tractor demonstrates a clear relationship between pulling force (kN) and forward speed. As the velocity escalated, the pulling force correspondingly intensified, with a minimum forward speed of 2.62 km/h yielding a pulling force of 2.62 kN, but the maximum pulling force was attained at a higher speed of 6.62 km/h, equating to 2.64 kN. The rise in the tractor's operational speed during soil smoothing may have resulted in heightened resistance encountered by the rotating plow, hence increasing the pulling force. These results align with the conclusions drawn (Moeinfar *et al*., 2020).

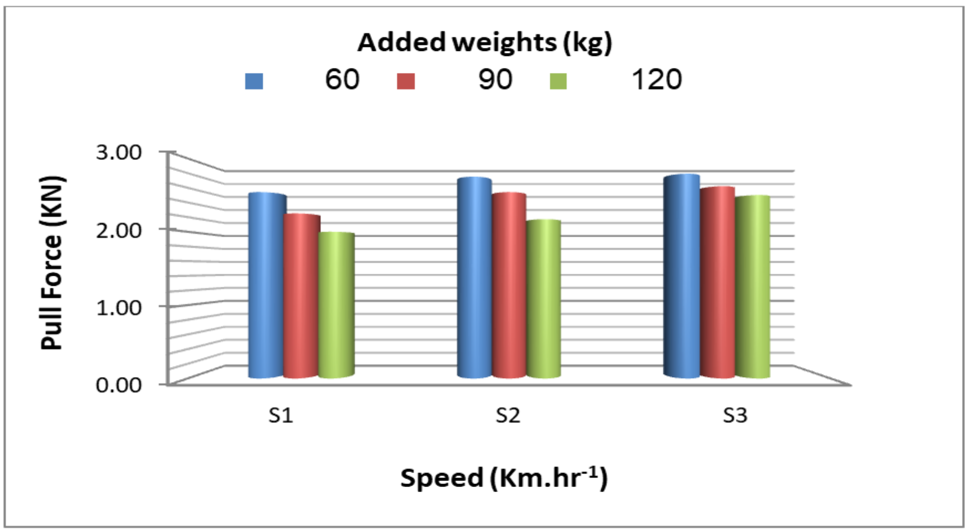

Figure 7 Effect of tractor speed and adding weight in pull force for the rotary plow.

The figure shows The significant impact of the weight addition factor on the pulling force during rotary plow operation: when the weights climbed from 60 to 90 and subsequently to 120 kg, the pulling force diminished from 2.69 to 2.47 and then to 2.22 kilonewtons. This reduction may be ascribed to the fact that augmenting the weights enhances the contact area of the wheels with the ground, hence diminishing slippage and subsequently decreasing the pulling force necessary for soil preparation tasks utilizing the rotary plow (Nuaimi and Rijabo,2020).

Figure (8) shows the effect of tractor speed, added weights, and the interactions between them on the drawbar power (kw) using the Two-Bottom Moldboard Plow. The tractor's speed has a notable impact on drawbar power, as The acceleration from 2.58 to 4.50 and then to 6.48 km/hr resulted in a rise in drawbar power from 2.63 to 4.85 and then to 7.55

kW. The reason for this may be due to the fact that the practical speed is one of the compounds included in the calculation of the drawbar power and is directly proportional to it (Russini *et al*., 2018).

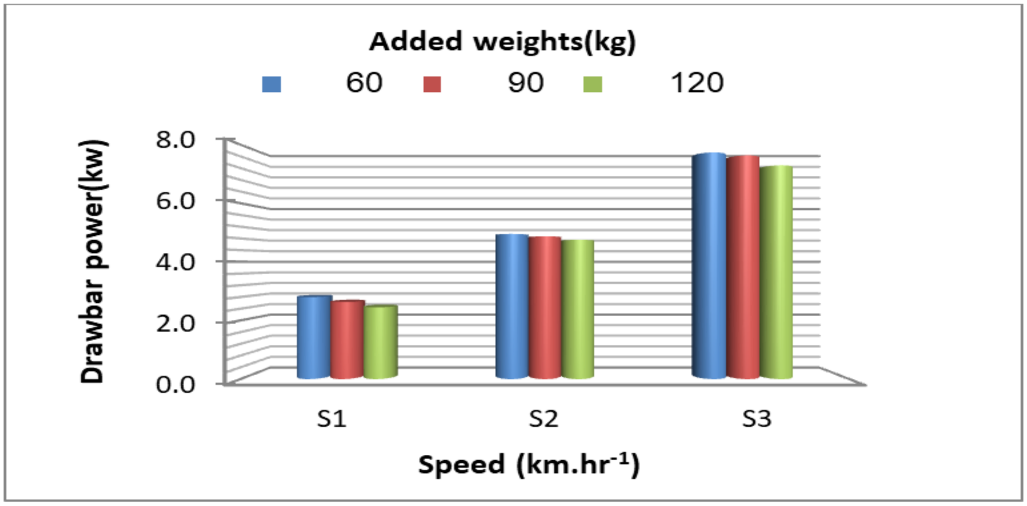

Figure 8 Effect of tractor speed and adding weight in drawbar power for the moldboard plow

It is clear from the figure the significant effect of the factor of adding weights on the tractor on the drawbar power using two-bottom moldboard plow, when the weights were increased from 60 to 90 and then to 120 kg, a decrease in the drawbar power from 5.16 to 5.04 and then to 4.83 kw,the reason for this may be due to a decrease in the drawbar power by increasing the added weights, which are directly proportional to it.
Figure (9) shows the impact of tractor velocity and added weights and the interactions between them on the drawbar power (kw) using the rotary plow in conducting soil smoothing operations. The tractor's speed significantly influences the drawbar power, as the increase in the forward speed from 2.62 to 4.67 and then to 6.69 km/h led to an increase in the drawbar power from 1.64 to 3.22 and then to 4.90 kW. This could be attributed to the gardener tractor's small size, which necessitates a simple pulling force directly proportional to the drawn power. These results are in agreement with the findings of (Monteiro *et al*.,2013). The figure shows the significant effect of adding weights on the rear axle of the tractor on the drawbar power using the rotary plow, when the weights were increased from 60 to 90 and then to 120 kg, it resulted in a decrease in the drawbar power from 3.48 to 3.26 and then to 3.02 kw,the reason for this may be due to a decrease in the Traction force required from the tractor during Smoothing operations, due to the decrease in the load on the tractor, which depends in its movement on the shaft of the power take-off [PTO] of the tractor, which means the need to do less work, which led to a decrease in the drawbar power (Rijabo and Thanoon,2018).

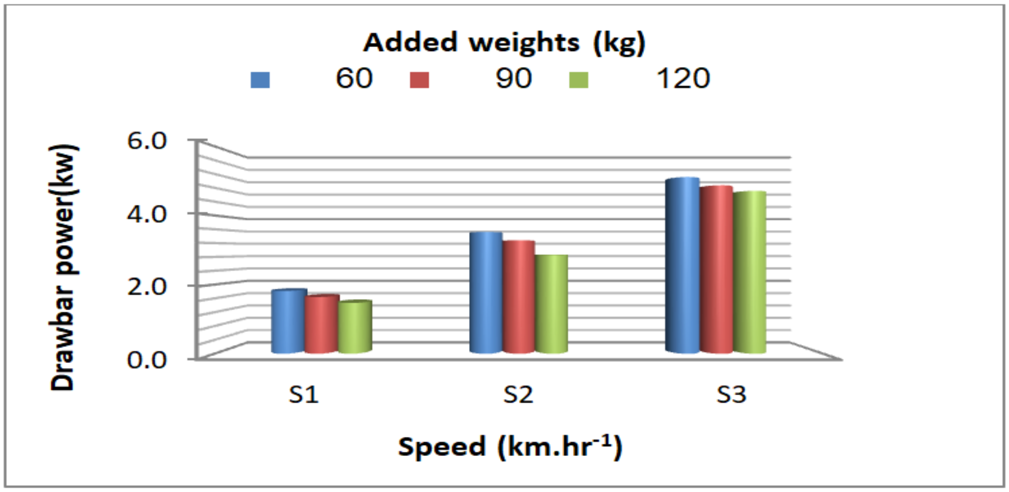

Figure 9 Effect of tractor speed and adding weight in drawbar power for the rotary plow.

Figure (10) shows the Impact of tractor velocity and additional weight and the interconnections among them affecting the percentage of slippage using the two-bottom moldboard plow, where the increase in speed from 2-.58 to 4.50 and then to 6.48 km/ h led to an increase in the percentage of slippage from 7.70 to 10.98 and then to 12.43% [4,11] . This may be attributable to the increase in the traction resistance as a result of increasing the speed and reducing the chance of the wheels cohesion by elevating the velocity of the tractor relative to the ground and thus a rise in the values of the slippage ratio and this aligns with the findings obtained by (Saadat and Savand, 2024 ; Jebur et al.2024).

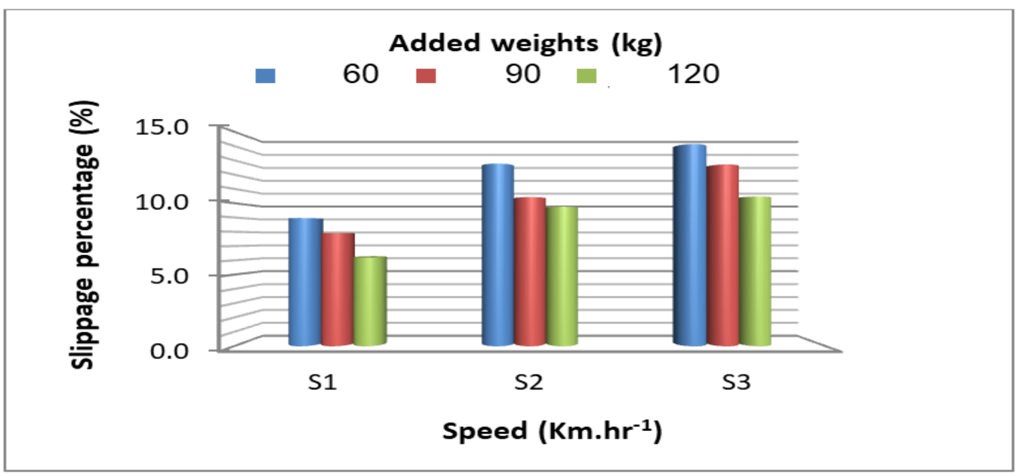

Figure 10 Effect of tractor speed and add weight in slippage percentage for the moldboard plow.

It is clear from the same figure the significant effect of adding weights to the rear axle of the tractor in the percentage of slippage (%) using moldboard plow, when the weights were increased from 60 to 90 and then to 120 kg resulted in a decrease in the slippage percentage from 11.95 to 10.34 and then to 8.81%. This may be attributed to the increased contact area between the wheels and the ground resulting from the addition of weights, which leads to a reduction in slip, as well as the increase of weights results in an increase in the soil's strength beneath the wheels, which reduces slipping. These results are consistent with the results reached (Darshana, *et al* .,2018 ; Mamkagh,2019). Figure (10) shows the effect of the tractor speed and the added weights and the interactions between them on the percentage of slipping using the rotary plow. It is noted that the significant effect of the tractor speed is observed, as the increase in the forward speed of the tractor from 2.62 to 4.67 and then to 6.69 km/h led to an increase in the percentage of slipping from 6.47 to 7.54 and then to 9.65%, The cause of this may be attributed to the enhanced operational speed of the tractor, resulting in a reduced likelihood of wheel adhesion to the ground, hence increasing slippage, which aligns with the obtained data (Kim *et al*., 2020) .

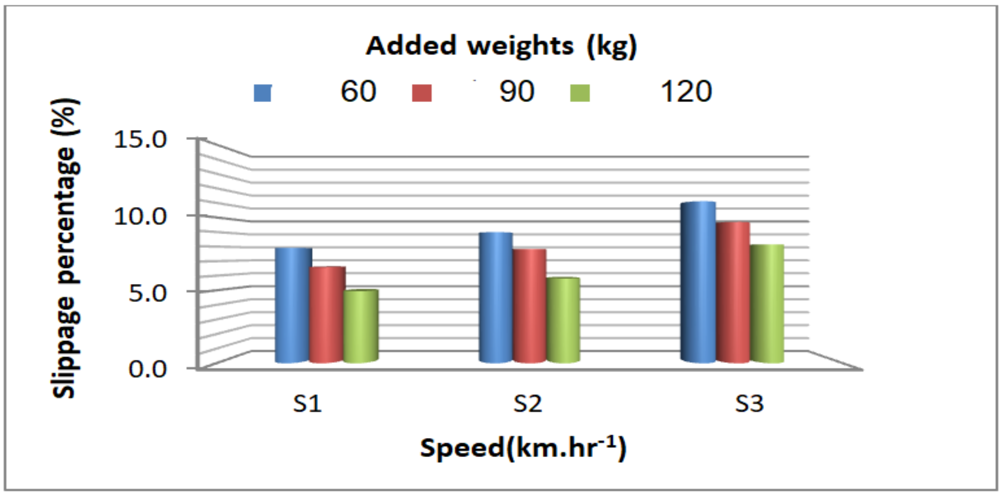

Figure 10. Effect of tractor speed and adding weight in slippage percentage for the rotary plow

It is clear from the same figure the significant effect of adding weights on the rear axle of the tractor in the percentage of slippage % using the rotary plow , so when you increase the weights from 60 to 90 and then to 120 kg, a decrease in the percentage of slipping results from 9.34 to 8.03 and then to 6.30%, The reason for this may be due to the fact that high speeds had the highest effect of adding weights on wheel slip, which led to lower values when performing soil Smoothing operations (Idas *et al*.,2024).

Conclusions and recommendations:

The increase in garden tractor speed resulted in a reduction in total cost values, an augmentation in pulling force and drawbar power, and a drop in slippage percentage. The increase of additional weights correlated with a reduction in the slippage percentage, pulling force, necessary drawbar power , and total costs. The New Holland T1520 agricultural tractor can be utilized for tillage operations with a moldboard plow at a velocity of 6.48 km/h and an additional weight of 120 kg, as well as for smoothing operations with a rotary plow at a speed of 6.69 km/h and the same added weight, yielding optimal results.

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