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THE EFFECT OF THE TIRE INFLATION PRESSURE AND THE ADDED WEIGHT TO THE TRACTION WHEELS ON SOME OF THE TRACTOR FIELD PERFORMANCE PARAMETERS OF 2WD (MF285S)

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SUMMARY

This research was conduct to investigate the effect of the tire inflation pressure and the added weight to the traction wheels on the power available at the traction wheels, the draft power and the rolling resistance. Four tire inflation pressure values (0.5, 1.0, 1.5 and 2.0bar) and four weights (0, 150, 350 and 450kg) were used. The experiments were conducted on MF285S tractor of two wheels drive (2WD). The results showed that the tire inflation pressure of 1.0bar surpassed the other tire inflation pressures, it gave the highest P_F (16kW) which occurred at F of 18kN while tire inflation pressure of 1.5bar came second, it gave P_F of 14.5kW which occurred at F of 17kN, while tire inflation pressure of 0.5bar came third (12kW, at F of 15kN) and the tire inflation pressure of 2.0 was last (10.5kW at F of 14kN). The power at the traction wheels was not used completely due to the limit soil strength. The power losses in wheels slip and the rolling resistance (P_d-P_F) increased as the draft force increased. It was higher for inflation pressure of 2.0bar it approached 18kW (66% of P_d) at F of 20kN, while it was the lowest for tire inflation pressure of 1.0bar (8kW) and it composed 33% of P_d while it was medium for tire inflation pressures of 0.5 and 2.0bar. The addition of weight to the traction wheels increased P_F when F is constant, At F value of 15kN, P_F increased from 12 to 13, 16 and 18kW, 450 kg increased P_F by 50%, when zero weight (dynamic weight of the traction weight is 17.37kN), 250kg (19.82kN), 350kg (20.8kN) and 450 (21.78kN) were added to the traction weigh respectively. The power losses decreased from 18kW to 9kW (50%) when zero and 450kg were added to the traction wheels at F value of 20kn respectively. For 250 and 350kg weights the power losses were medium.

The lowest rolling resistance was recorded for inflation pressure of 1.25bar. The rolling resistance increased with added weight but the tire inflation pressure of 1.5bar gave the lowest value while 1.5 became second.

Keywords: Draft force, draft power, power available at the traction wheels and rolling resistance

1.0 Introduction

The tractors are mainly designed to provide draft and (power take off) PTO powers for the agriculture implements. The draft power is for the draught implements while the PTO power for the rotary implements. The source of both types of powers is the tractor engine which depends upon the design feature of the engine. The engine power (Brake Horse power) is transferred to the wheels through the transmission systems [1,2,3]. The power at the traction wheels depends on the efficiency of the transmission systems

[3,4,5]. The power at the traction wheels is transferred to the drawbar as draft power which depends on the traction efficiency. The traction efficiency on the other hand depends on the relationship between the traction wheels and the soil. When this relationship is weak the losses through the wheels slip and the rolling resistance which acts on the wheels are high and that reduces the draft power which affects the tractor traction ability negatively [2,6,7,8]. The wheels slip can be reduced to some extent by adding weight to the traction wheels to increases the soil strength at the contact area of the traction wheels. However, adding weights to the traction wheels increase the rolling resistance of the traction wheels so when weights are added their effect on the rolling resistance should be taken into account [2,7,9]. The extra weight increases the tire sinkage in the soil which makes rut. The rut depth depends on the weight, soil strength and tire dimensions and tire inflation pressure. The wheels slip is affected by the tire inflation pressure [3,10,11]. The tire inflation pressure is regarded as the second important factor which effect the tractor field performance such as the draft power [4,5,12], so this research will investigate the effect of the tire inflation pressure as well as the added weights to the traction wheels and the interaction between them on the power at the traction wheels, draft power and the rolling resistance of the tractor.

Four tire inflation pressures are used (0.5, 1.0, 1.5 and 2.0bar) and four added weights (0 (control treatment), 250, 350 and 450kg). The experiments were conducted using four forward speeds and different operating depths to obtained deferent draft power. The tractor under test was loaded by using moldboard and subsoiler plows. The subsoiler was used for greater operating depths to obtain higher draft power.

2.0 Materials and Methods

2.1 Tractor MF 285S

The tractor under test is Massy Ferguson 285S (MF285S). The tractor was made in 1995 by Uzel company, Turkey. The tractor is two wheel drive tractor (2WD) provided with diesel engine of Perkins type. The brake power is 56.6kW (77HP). The engine is four strokes type and its compression ratio is 16:1. The engine is provided with rotary type fuel pump. The gear box is of synchromesh type gives eight forward gear ratios, four heavy and four light gears and two back gear ratios. The tractor total weight with all tanks (fuel, water and oil) completely filled is 30kN (3058.1kg). The weight carried by the rear and front wheels are 17.37 (1770.64kg) and 12.63kN (1287.46kg) respectively. The rear and front tires sizes are 18.4/15-30 and 16-7.5 respectively. The lugs height and width of the rear tire lugs are 4 and 4 cm respectively. The inclination angle of the lugs relative to the center line of the tire is 45^o. The inflation pressure of the front tires is 2.5bar and it was remained consistence during the test experiments.

2.2 Plows of the experiments

Moldboard and subsoiler plows were used to load the tractor to study its field performance. The moldboard plow is three- body of deep digger type. The working width of the plow is 1.22cm. The plow was used at different operating depth in the field. The subsoiler plow was of single tine type. It can penetrate the soil up to 70 cm. The rake angle (the forward angle) of the shank is 70^o and the attack angle of the foot is 30^o. It was used at deep operating depth of 30cm to obtained different draft force of high values.

2.3 The added weight to the traction wheels

Three weights (250, 350 and 450kg) were added to the traction wheels (rear wheels). Load carrier was manufactured and fixed above the center of the rear wheels.

2.4 Draft force, draft power and the power available at the traction wheels

The draft force was measured in the field for different plowing depths and forward speeds as it was discussed in details in [13] The draft power is calculated by the following equation:

$\mathbf{P_F = F * V_a}$

Where $\mathbf{P_F}$= draft power (kW)

F= draft force (kN)

$\mathbf{V_a}$= tractor forward speed (m/sec)

The power at the traction wheels is calculated as follows:

$\mathbf{P_d = H * V_t}$

Where $\mathbf{P_d}$=power at the traction wheels (kW)

H= thrust (kN)

$\mathbf{V_a}$= tractor theoretical forward speed (m/sec)

The trust can be calculated as follows:

H= F+R

Where **R**= rolling resistance (kN)

2.4 The theoretical forward speed and wheel slip

The tractor theoretical forward speed (MF285S) was measured on a hard surface. The tractor engine speed was set at 1500rpm and its gear box was put on gear (for example G_1h). Then the tractor was left to move distance of 5m to approach the maximum forward speed and then left to move another 20m and the time taken to move this distance was recorded. The theoretical forward speed was calculated as fallows:

V_t= D/ T …………(3)

Where Vt= theoretical forward speed (m/sec)

D=distance of 20m

T= the time taken to move 20m.

The wheel slip (S)of the tractor traction wheels (rear wheels) was calculated as follows:

S=[Vt – Va]/Vt …………(4)

2.5 The rolling resistance

The rolling resistance of the tractor under test (MF285S) was measured by towing it by another tractor using the hydraulic dynamometer and the flexible cable. The same theoretical forward speed was used. The measurements were carried out on the same soil of the experiments. Each run was repeated three times and the mean was taken.

3.0 Results and Discussion

3.1 The relationship between the draft power, the power at the traction wheels and the draft force for different inflation pressures

The relationship between the power at the traction wheels, the draft power and the draft force for tire inflation pressure 0.5, 1.0, 1.5 and 2.0bar, figure (1). P_F increased as the F increased to approach the maximum value which differed for the tire inflation pressures. The maximum values occurred at F of 14, 15, 17 and 18kN for tire inflation pressures of 2.0, 0.5, 1.5 and 1.0bar. These values were higher than that found by Aday et al (2002) for Antor 71 tractor and Aday et al (2003) for MF 285S tractor. The superiority of the tire inflation pressure of 1.0bar on the rest of the inflation pressures was that the power losses by the wheel slip and the rolling resistance were at minimum. This tire inflation pressure increased the ability of the tire to grip the soil and that reduced the wheel slip and the tire sinkage in the soil because the contact area is enough to provide a bearing area to withstand the weight of the wheels. P_F decreased after the maximum value but the rate of decrease was greater for the inflation pressures of 0.5 and 2.0bar than for the inflation pressures of 1.5 and 1.0bar. The first two inflation pressures had grater draft power losses by the wheels slip compared with second inflation pressures. P_d is the power transferred from the tractor engine to the traction wheels by the transmission systems. It depends on the transmission system efficiency. The consumption of the power at the traction wheels increased as P_F increased and this means at higher P_F the tractor can use great deal of power at the traction wheels which reduces the power dissipation. The difference between the P_F and the P_d represents the power dissipated in the wheels slip and the rolling resistance. At the lower F the difference between the two powers is low and increased as F increased to become greater after the maximum value of F. At the beginning, the wheels slip is low because F is small but when F increased the tractor developed greater thrust which accomplished with higher wheels slip and the later means higher power dissipation. After the maximum value of P_F the power losses became sever and that was because the soil strength underneath the traction wheels approached its maximum value and started to deform heavily. However the power losses depend on the tire inflation pressure, it decreased as follows: 2.0, 0.5, 1.5 and 1.0bar respectively. For example, at F of 10kN the power loss was 7kW for the tire inflation pressure of 2.0bar which represents 40% of used Pd, while for the tire inflation pressure of 1.0bar the power loss was 3kW which represents 21% of used Pd. The power losses increased appreciable when the draft force increased. At F of 20kN the power loss with tire inflation pressure of 2.0bar increased to 16kW (62% of Pd) which means the power losses was higher than P_F (38% of Pd), For the tire inflation pressure of 1.0bar the losses was lower than that for tire inflation pressure of 2.obar but it was in general high, the loss is 8kW (33% of Pd) which is half of that for tire inflation pressure of 2.0bar. Therefore, for less power losses the tractor should not exceeded F of 15 and 18kN for tire inflation pressures of 2.0 and 1.0bar respectively. The tire inflation pressures of 1.5 and 0.5bar were being medium, but the inflation pressure of 1.5bar is better than 0.5bar and became second.

3.2 The relationship between the draft power, the power at the traction wheels and the draft force for different added weights

The relationship between the draft force, the power at the traction wheels and the draft force for added weights to the traction wheels (0, 250, 350 and 450kg) is shown in figure (2). The weight of the traction wheels plays great roll in proving the tractor traction, so when 250kg (2.45kN) was added to the traction wheels P_F increased from 12kW with out adding weight (the weight of the traction wheels, rear wheels, is 17.37kN) to 13kW. When 450kg (4.41kN) was added P_F increased to 16kW (25%) and this increase was because the power losses by the wheels slip decreased considerable due the improvement in the soil strength underneath the traction wheels. The maximum values of P_F were also increased from 12 to 13.4, 15.5 and 17kW when 250, 350 and 450kg were added to the traction wheels. F at which the maximum P_F occurred increased also from 15 to 16.7, 17.3 and 18kN respectively and that means better usage of the power at the traction wheels. The added weight reduced the power losses considerably and that can be seen from the difference between P_F and P_d especially after the maximum values of P_F where the soil strength became closer to the maximum values. For example, at F of 15kN the power loss was 7kW (P_d- P_F) for zero weight added, it decreased to 3.5kW when 450kg was added to the traction wheels and that means big power losses was retained which can be used for draft. When F was increased to 20kN the power losses increased to 18kW for zero added weight while P_F was only 8kW which is lower by 10kW (66%) and this means great power losses which gives very low traction efficiency. But when 450kg was added to the traction wheels the power losses decreased to 9kW (50%) , saving 9kW which can provides 9kN when the tractor moves at forward speed of 1m/sec. This big gain in P_F is related to the lower losses in wheel slip because the tires grip the soil firmly. The results showed that P_d was not used completely (straight lines of Pd) and an excess power was available at the traction wheels and it was not used because the soil strength was not great enough despite of the addition of the weight. This means bigger weight is required.

3.3 The relationship between the rolling resistance and the added Weight to the traction wheels for different tire inflation pressures

The relationship between the rolling resistance of the tractor and the weight added to the traction wheels for different tire inflation pressure (0.5, 2.0, 1.5 and 2.0bar), figure (3). The rolling resistance increased as the weight increased and that was because the tire sinks in the soil forming a rut which required extra power to overcome the resistance exposed by the soil on the tire when trying to get out the rut. The weight also increases the tire deflection which needs power to retain the tire to its original shape which is regarded as power losses source. This result was also found by Sirios and hassan (1984), Aday (1993) and Milanze (1997).

The rolling resistance also depends on the tire inflation pressure. It increased for tire inflation pressures as follows; 1.0, 1.5, 2.0 and 0.5 bar. The lower and higher tire inflation pressures gave higher rolling resistance because the lower tire inflation pressure causes big tire deflection which requires great deal of power to retain the tire to its circular shape. The higher inflation pressure hardens the tire and that causes deep rut in the soil which required greater power from the tire to climb it when moving forward. However, the tire deflection due to the low inflation pressure surpassed the tire hardness due to the high inflation pressure.

The best tire inflation pressure gave the lowest rolling resistance was 1.0bar and the second best tire inflation pressure is 1.5bar. The superiority of inflation pressure of 1.0bar was gave medium tire deflection which required less power to retain to the origin shape and give enough contact area which reduced the tire sinkage to minimum.

3.4 The relationship between the rolling resistance and the tire inflation pressures for different added Weight to the traction wheels

The relationship between the rolling resistance and the tire inflation pressures for different added weight to the traction wheels 90, 250, 350 and 450kg) shown in figure (4). The rolling resistance decreased considerably as the tire inflation pressure increased for all the weights added to approach the lowest values at inflation pressure 1.25bar and then increased as the inflation pressure increased. The rate of decreasing was greater than the rate of increasing. The decrease in the rolling resistance in the beginning was because the tire deflection decreased appreciable as the inflation pressure increased and that on other hand decreased the power required to regain the original shape of the tire. However, the increase in the pressure underneath the tire due to the reduction in the contact area which caused by the increase in the inflation pressure (weight of the tire/ contact area) had less effect on the rolling resistance compared with that of tire deflection.

After the value of the inflation pressure of 1.25bar at which the rolling resistance is at minimum, the tire hardness due to the inflation pressure increased the rolling resistance due to the soil compaction. While the tire deflection fated out gradually to dimension completely after the inflation pressure of 1.5bar. The results showed that the effect of the tire deflection on the rolling resistance was greater than the soil compaction due to the high tire inflation pressure.

The rolling resistance is higher for greater weight of the tires for the same inflation pressure due to the soil compaction.

3.4 The relationship between the rolling resistance and the tire inflation pressures for different tractor forward speeds.

The relationship between the rolling resistance and the tire inflation pressure for different tractor forward speeds is shown in figure (5).
The lowest rolling resistance was recorded at the tire inflation pressure of 1.25bar while it increased for higher and lower values than value of 1.25bar. The rolling resistance was greater for higher forward speed when the tire inflation pressure is constant. The effect of the tractor forward speed on the rolling resistance is through increasing the bow wave (number
of retaining tire to its origin per unit time) of the tire which require extra power.

Abbreviation:
Draft force=F, Draft power=P_F, Power available at the traction wheels=P_d

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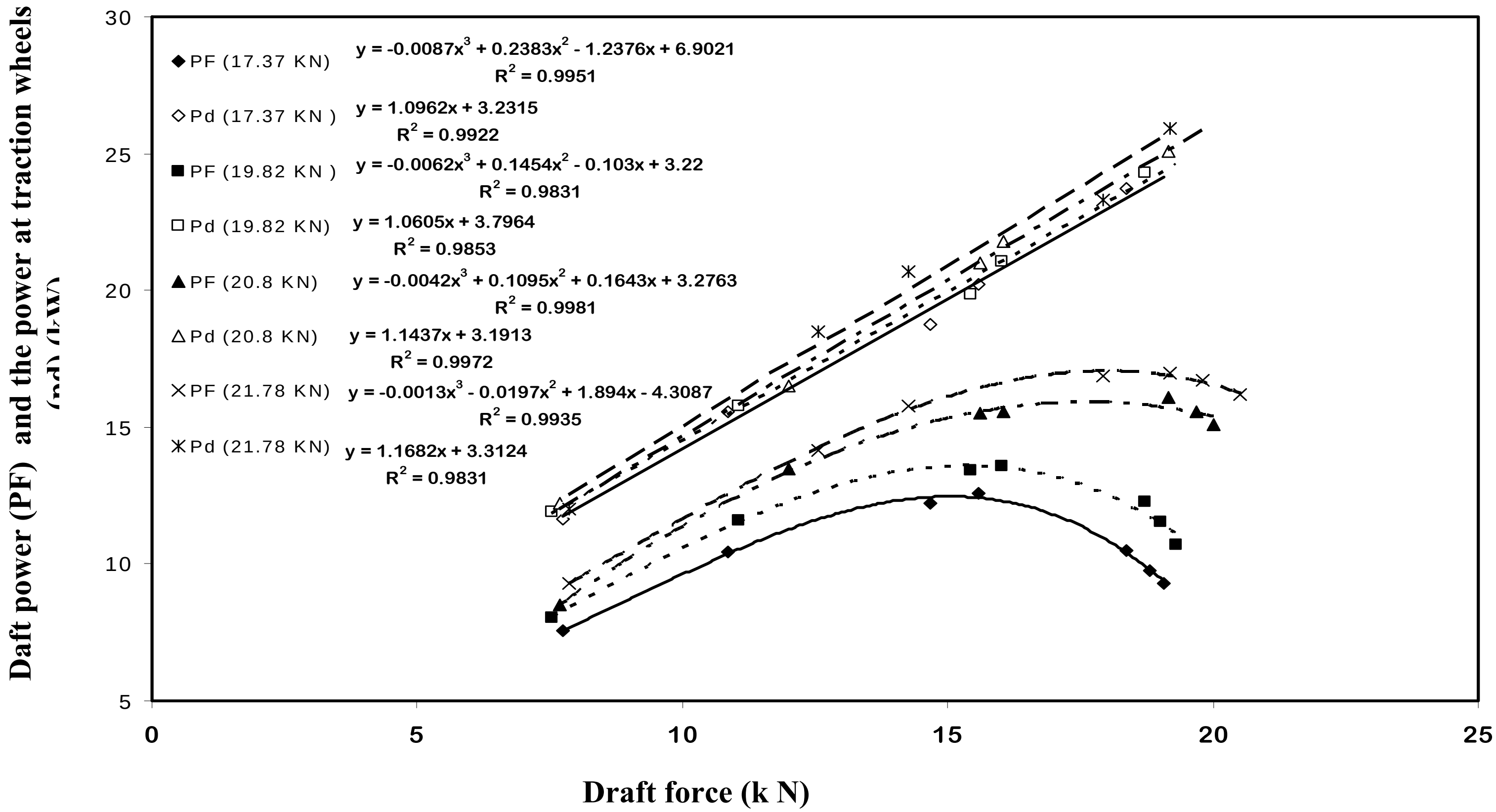
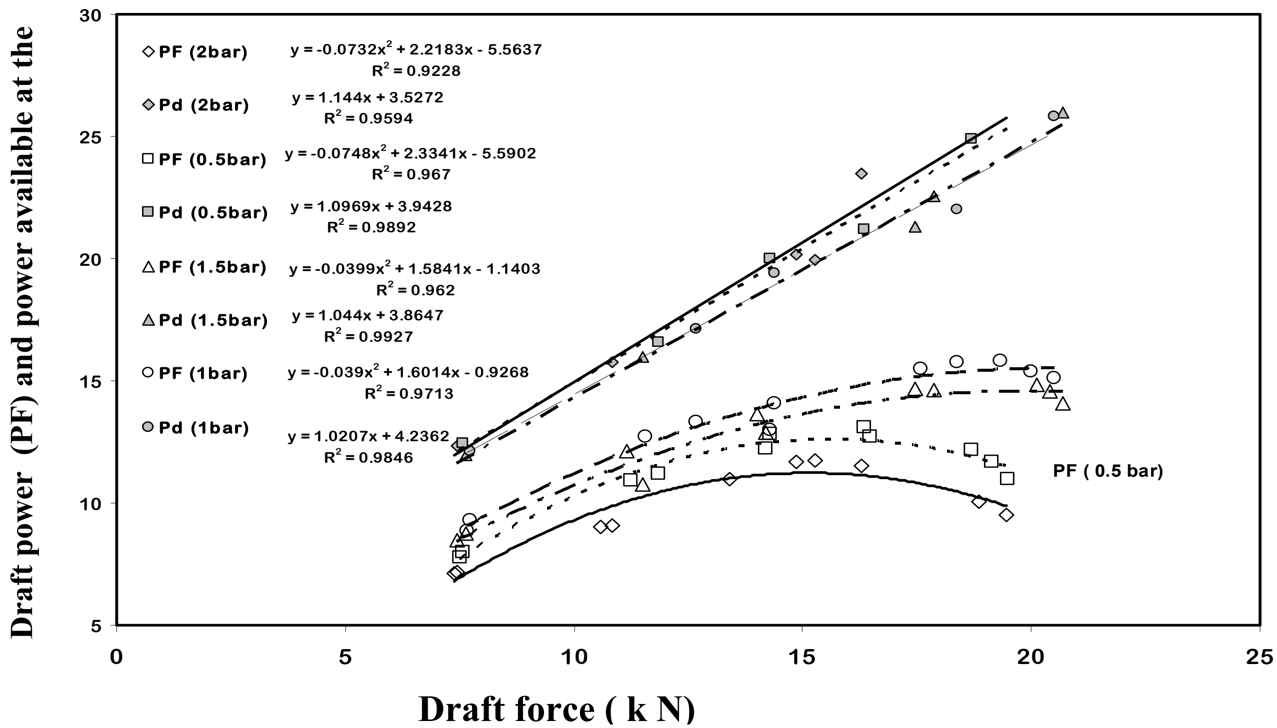


Figure(2):The relationship between the draft power (PF)and the power at the traction wheels (Pd) and the draft force of the tractor for different added weights (0, 150, 350 and 450kg)



Figure(1): The relationship between the draft power (PF) and the power at raction wheels and the draft force for different tire inflation pressure of the tire.

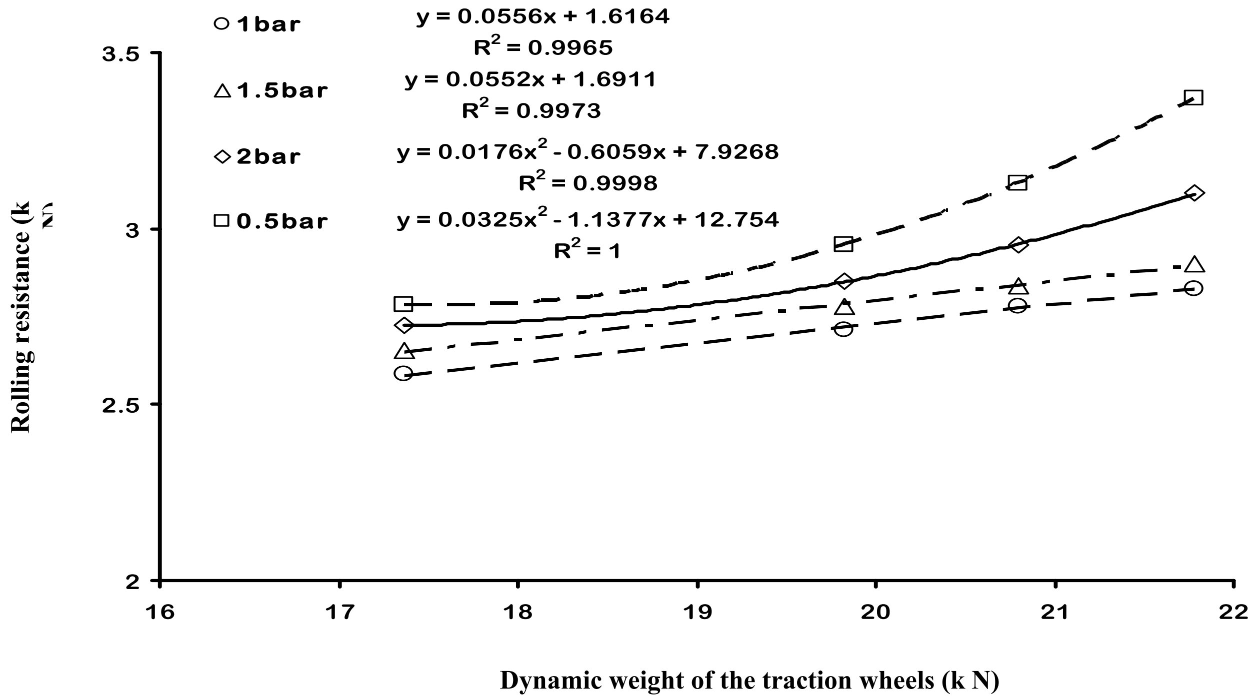
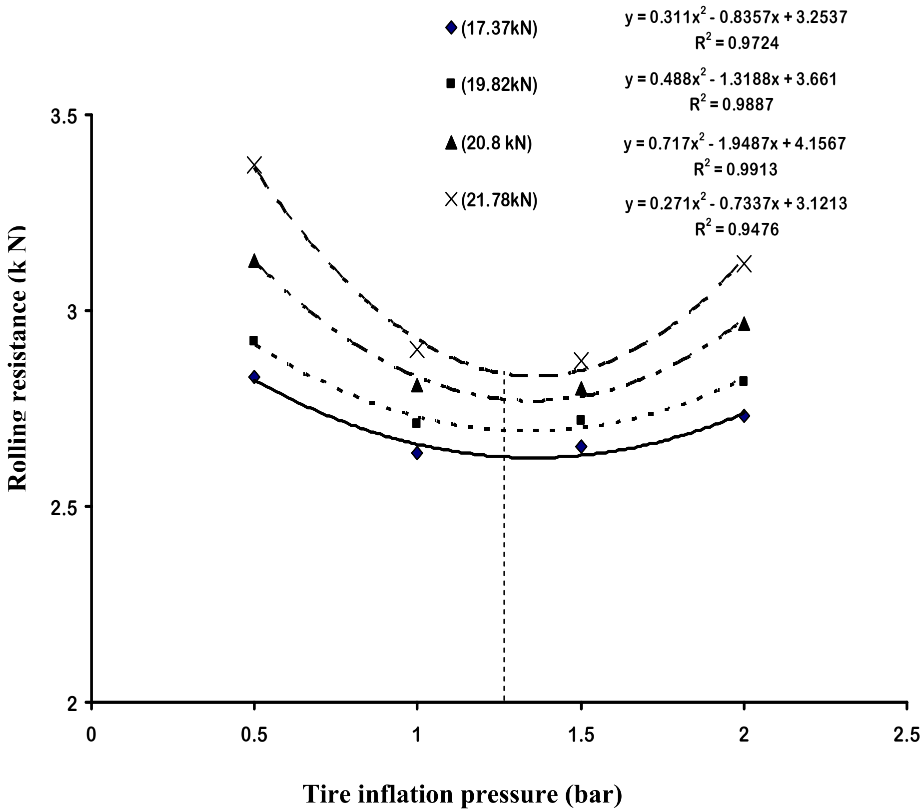


Figure (3): The relationship between the rolling resistance of the tractor and dynamics weight of the rear wheels (with the added weight of 0, 250, 350 and 450kg) for different tire inflation pressure



Figure(4): The relationship between the rolling resistance of the tractor and the inflation pressure of the tire for different weight of the traction wheels (added weights 0, 250, 350 and 450kg).

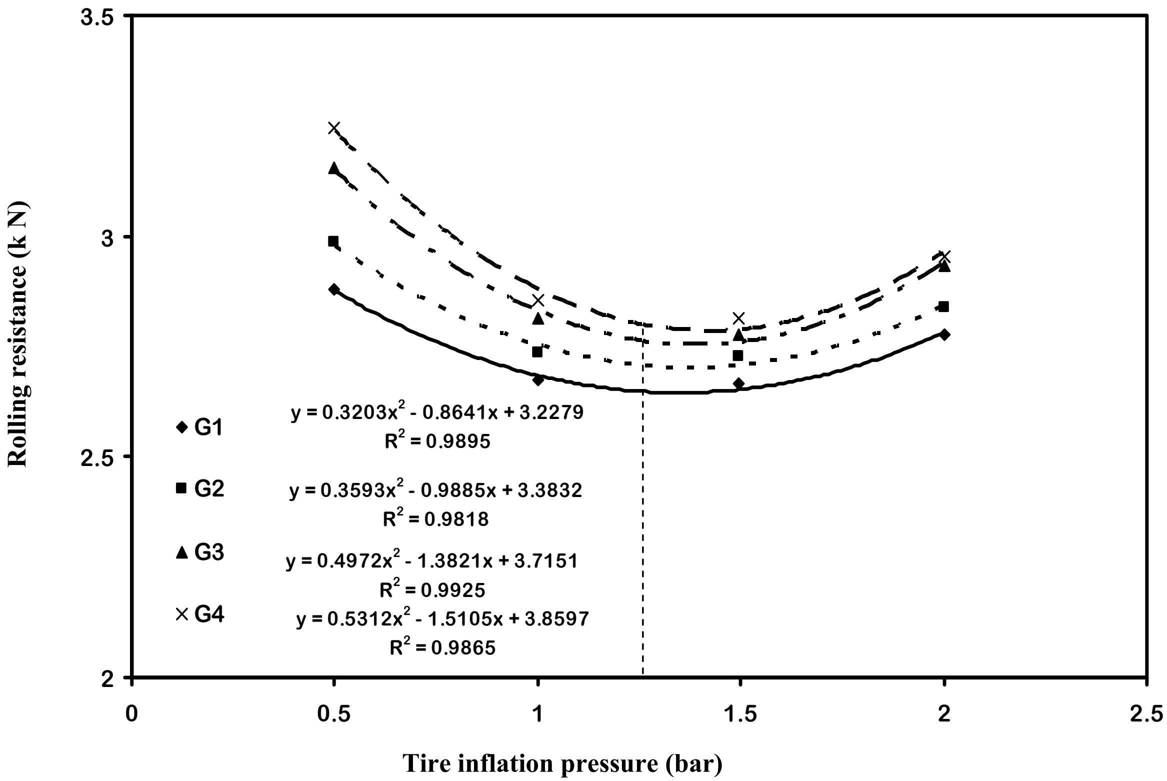


Figure (5): The relation ship between the rolling resistance and the inflation pressure of the tire for different forward speeds.

تأثير ضغط هواء إطارات الدفع والوزن المضاف أليها على بعض عوامل أداء الحقلي للجرار الذي يولد دفع بعجلاته الخلفية (MF285S)

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الخلاصه

أجرى هذا البحث لدراسه تاثير ضغط هواء اطارات الدفع والوزن المضاف اليها على قدره السحب والقدره المتوفره عند اطارات الدفع وعلى مقاومه التدحرج التى تؤثر على الاطارات. ضغوط الهواء والاوزان التى اسنخدمت فى التجارب هى 0.5, 1.0, 1.5, 2.0bar و 0, 250 350, 450kg الصفر معامله المقارنه. أستخدمت سرع اماميه واعماق حراثه مختلفيه وباستخدام محراثين احداهما قلاب والاخر تحت سطح التربه. أظهرت النتائج تفوق ضغوط هواء الاطاروكما يلى 1.0، 1.5، 0.5، 2.0 bar اذ اعطوا قدر سحب قصوى 16، 14.5، 13.5، 10.5 kW والتى وقعت عند قوى سحب 16، 15.5 ، 14، 10.5 kN على التوالى. اما القدرة المتوفره عند عجلات فلم تستخدم كلها بسب ضعف التربة، زاد الاختلاف بين ألقدره المتوفره عند العجلات وقدره السحب والتى تمثل ألقدره المفقودة بانزلاق عجلات الدفع ومقاومه التدحرج مع زياده قوة السحب، ان أعلى فقد بالقدره سجل لضغط الاطار 2.0 bar وبمقدار 18 kW والتى تشكل نسبة 66% من القدره المستهلكة من ألقدره المتوفرة بعجلات وقل قدره مفقوده سجلت لضغط الاطار 1.0 bar والتى بلغت 8 kW والتى تشكل نسبه 33% من ألقدره الموجودة عند الجلات بينما كانت وسط بين الاثنين لضغطي الاخرين.

زادت قدره السحب بصوره واضحة عند أضافه وزن إلى عجلات الدفع، فقد زادت من12، 13 ،16 ، 18 kW عند اضافه zero ،250 ، 350 ،450 kg الى عجلات الدفع وعند قوه السحب 15 kN وعلى التوالى. كما نخفض الفقد بالقدره من 18 الى 9 kW (50%) عند اضافه 450 kg مقارنه بعدم اضافه وزن الى عجلات الدفع بينما للوزنين الاخرين كان الفقد وسطا.

أظهرت النتائج اقل مقاومه تدحرج سجلت عند ضغط هواء 1.25 bar بينما زادت مع زياده ونخفاظ ضغط الهواء عن القيه المذكوره. زادت مقاومه التدحرج مع زياده الوزن والسرعه الاماميه للجرار.