A STUDY ON AGRICULTURAL TRACTORS STEERING MECHANISM

5-THE Plowing tests (Field capacity-efficiency-costs)

***Sarhan, A. M. M. **Al – Katary, H. S. ***El- Awady, M. N.**

ABSTRACT

The main aim of this research was to increase the operation efficiency of agricultural tractor to suit the conditions and potentials of the Egyptian farmer. This leads to increase the rates of the feddan production and raise the value of the yield per feddan. This meets the requirement to achieve the strategic goals of the agricultural development by modifying and developing the modern technology, especially the agricultural tractors to suit the local environment in all agricultural operations, including plowing. Laboratory experiments and statistical analysis for the data of the research were run and hydraulically steering was designed by suing a closed hydraulic circuit for the tractor. The main results obtained from the experiments are summarized in the following main points:

1-Mathematicl equations are derived to find the turning time every agricultural operation.

2-Maximum the saving percentage turning time, total time and costs of operation of about (55.2; 13.63; 18.37%) at the value of W/WB of about 0.39 respectively compared with the tractor before modification. 3-Decreasing the repeated technical problems in the steering equipments of the tractors. 4-Decreasing the operation, maintain and used spare parts in the steering equipments of tractors. 5-The modification suits all the agricultural operations even for small holdings in Egypt.

INTRODUCTION

The agricultural tractor is the backbone of the Egyptian agriculture because it does all the different field processes. It must be improved to suit the conditions and potentials of the Egyptian farmer to increase the efficiency of its operation. This study aims to develop steering in particular. It aims to design a mechanism which can

*Ph. D. Stud. Dept. Eng., Fac. Agric., Al-Azhar Uninv. Cairo Egypt .
**Prof., Agric. Eng. Dept., Fac. Agric., Al-Azhar Uninv. Cairo Egypt .
***Emt. Prof., Agric. Eng. Dept., Fac. Agric., Ain Shams Uninv.

Be it aims to design a mechanism which can be controlled hydraulically to work on the front land-wheels.

1- The time:

Liljedahl et al. (1959) found that the roll-o-matic front end on the John Deere **70** reduces average, maximum manual steering forces **25** percent when cultivating corn the second time and when loading manure with the John Deere **70** tractor, power steering reduced the loading time by **10** percent. ***Kamel (1987)*** reported that the rate of work increased as the furrow length increased due to the increase in actual working time and decrease in the time loss.

2- The field capacity:

Hindey et al. (1998) found that tillage with combined unit at implement forward speed of **2.57** km/h, soil moisture content of **20.24%** and plowing depth range of **19.1** to **19.8** cm. produced the greatest corn yield **(4.73** ton/ fed., Kernel + cobs**) .**

3- The field efficiency:

Novikov (1991) carried out automation of cab controls designed for tractors and agricultural machinery as a means of increasing operational efficiency. Steering, electronic gauges, microclimate control etc., their connection to a central control panel, and subsequent information's processing by microcomputers, are mentioned. Some computer systems used, manufactured abroad **(**Germany, Austria, Canada**, UK)** were briefly assessed.

Nasr et al. (1998) concluded that the maximum value of field efficiency was at using **1**st speed for all different seedbed preparation implements, while the minimum value was when using **4**th speed for all different seedbed preparation implements. The maximum value of field efficiency was at using system **4,** while the minimum value was at using system **5.**

4- The fuel consumption:

Hamad et al. (1992) observed that the rotary plow represented the highest level of fuel consumption (L/fed.), followed by the moldboard and chisel plows, respectively. The moldboard plow represented the highest system in fuel consumption and the rotary was the lowest.

EL-Sayed and El-Kilani (2002) showed that the average values of predicted fuel consumption L/fed. Were 5.43, 9.04, 9.04 and 6.82 for chisel, mould board, disc and rotary ploughs, respectively. Meanwhile, the average values of measured fuel consumption were 5.65, 9.84, 10.83 and 7.38 L/ fed., respectively.

5- The costs:

Katary (1976) reported the following main points: **1-**For all tractor sizes the cost per feddan decreases as the field size increases for tested plows. **2-**For all holding sizes, the cost per feddan increases by the increase of tractor size (power).

MATERIAL AND METHODS

A- Tractor:

The Belarus tractor, **65B.HP (48.2kw)** was common and widespread under Egyptian conditions. The tractor is multi purpose of the model **10M3-6KM**. It was used in this research. The tractor was tested in plowing operation. After modification it was tested at agricultural tractors and machinery research laboratory, Agricultural Engineering Department, Faculty of Agriculture, Al-Azhar University.

A-1: The tractor before modification:

1- Gasoline engine **(65 HP, 48.2kw)** at **1750** rpm. **2-** Wheels (four wheels). **3-**Minimum turning radius = **5**m.

4- Steering system:

(A): The components: It consists of: **(1):**Front axle; **(2):**Steering wheel to track width adjustment mechanism, determining the front wheel toe-in and checking toe-in of steering wheels; **(3):**Sector, spool, bushing, steering gear case, rack and oil drain pipeline **(**Fig.**1); (4):** Steering column, shock absorbers, sleeve, steering wheel shaft and steering wheel**; (5):** Steering gear, steering arm, steering shaft and warm gear**;** (**6):** Hydraulic steering servo, housing, spring washer and front cover; **(7):** Mounted at the middle position on the tractor.

(B): The disadvantages of power steering:

1- Difficult to repair and maintain.
2- Costs of repair and maintance.
3- The spare parts price is expensive**.**
4- Complex construction.
5- Mechanical steering system with addition to hydraulic steering servo.

A-2: The tractor after modification:

The tractor was modified to overcome the problems encountered during the experimentation. The specifications of the tractor after modification are the same of tractor before modification but the deferent are follows:

Apparatus of power hydraulic steering system:

It was power hydraulic steering circuit, **(**Fig. **2):**

The components: It consists of: 1- Reservoir (Transmission housing); 2-Filter on intake; 2B-Filter on delivery; 3- Hydraulic pump. It consists of: A-Suction port; R-Lube fillets; I): Bearings; 2):Seals; 3):Cover; 4):Key; 8):Bearing; 9):Bushes; 10):Pipe union; 11):Pump body; 12):Engine block; 13):Conductor pinion; 4-Rotary valve; 5, 9- Check valve; 6-Pressure relief valve; 7-Hydraulic steering control valve: It consists of: 1): Fixing screw; 2): Lower cap; 4):Spacer; 6):Stator; 7): Rotor; 8):Intermediate flange; 9):Non return valve; 10): Pressure limit valve; 14): Distributor; 15, 18):Anti-cavitations valve; 6):Distributor body; 17):Anti-shock valve; 19):Short circuit valve; 21):Grooved hub; 25):Upper cap. 8- Transfer pump/motor; 17-Sleeve; 18-Anti-shock valves (cylinder safety valves); 19-Anti-cavitations valves (Makeup valves); 22- Power cylinder: It consists of: 1):Cylinder; 2):Locking; 3): Bearing; 4):Gland; 5):“O” Ring; 6, 12, 13):Seal; 7): Wiper seal; 8):Gland locking; 9):Cylinder rod; 10):Retaining Ring; 11):Piston.

23- Ducts: A-Intake; B- Delivery; C-Return; D-Users on LH side of power cylinder; E-Users on RH side of power cylinder; F-Anti-shock valve discharge; G- Transmission oil cooler; R-Flow regulator; W-Steering wheel.

B- Devices:

B-1: Surveying instruments:

Tape steel **20**m, arrows and steel ruler **30**cm were used for measuring and determining longitudinal dimensions. Pins were used for hitching the hydraulic dynamometer from both sides. Steel bolts and plastic threads were used for determining angle.

B-2: Fuel consumption apparatus:

Apparatus was made at the central workshop in Ministry of Agriculture and Land Reclamation, to measure tractor fuel consumption during the test. It had a gauging stick made of the adulterous wood, as shown in Fig.(3).Its capacity is 100 liters; it is divided into 250 divisions; each is reading 400 ML.

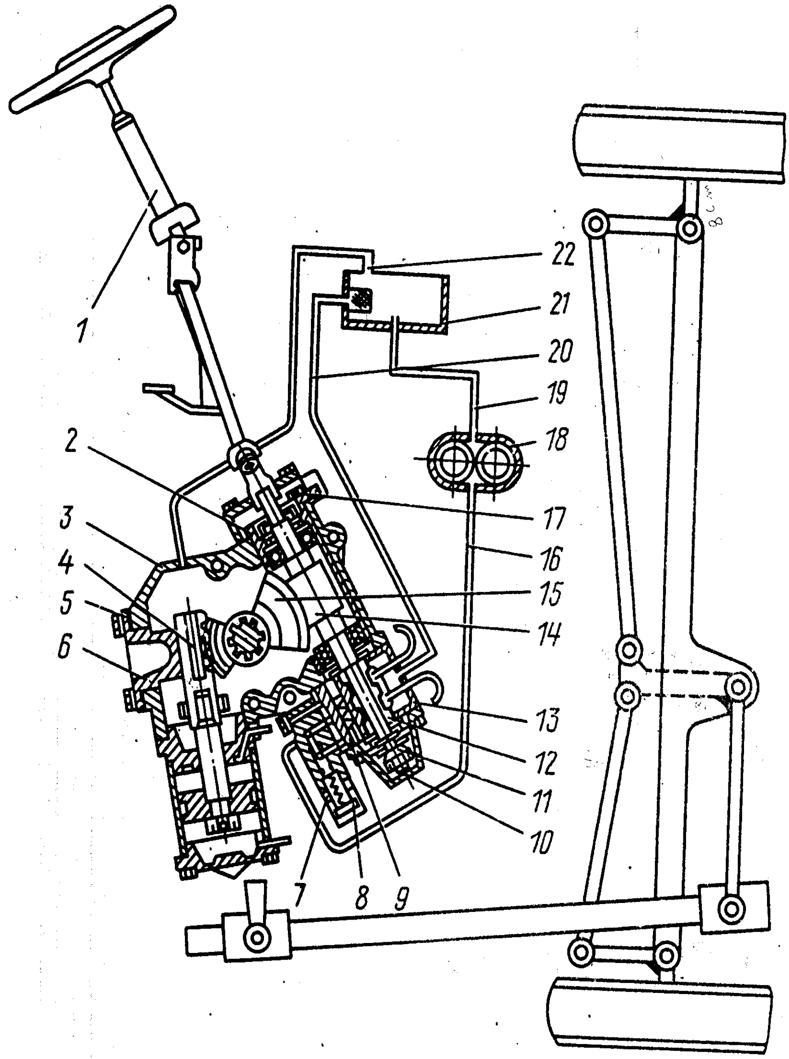

Fig. (1): Diagram of steering gear hydraulic Booster:

1- steering column ; 2- bushing ; 3- steering gear case ; 4- rack ; 5- gasket ; 6- rest 7- lock nut ; 8- screw ; 9- safety valve ; 10- cover ; 11- spherical nut ; 12 – spool ; 13- control valve housing ; 14- worm ;15- sector ;16- oil delivery pipeline ; 17- bolt ; 18- oil pum ;19 – oil suction pipeline ; 20- oil return pipeline ; 21 – oil tank ; 22- oil drain pipeline **(Gurevich and Sorokin,1976).**

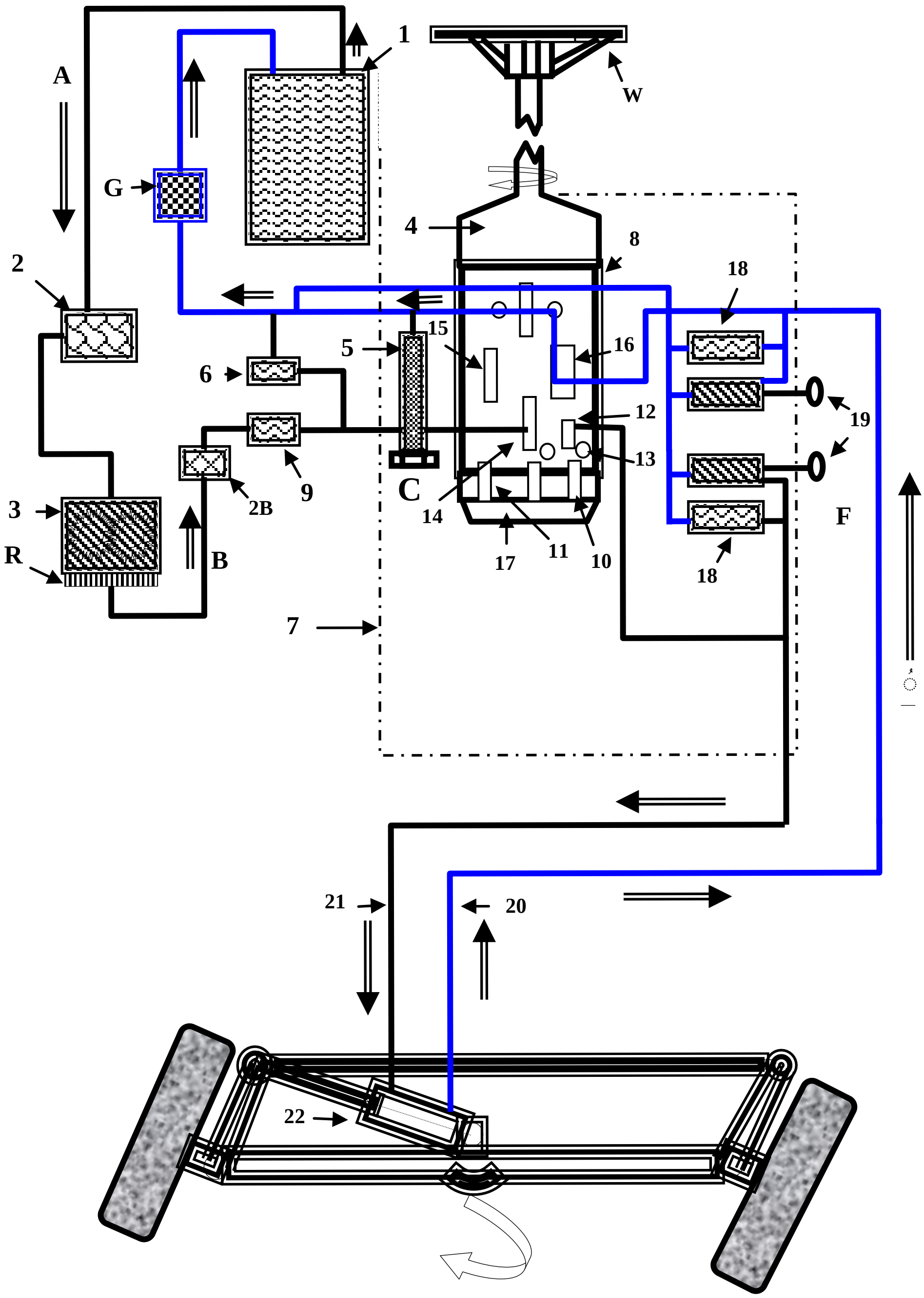

Fig. (2): Schematic drawing for apparatus of power hydraulic steering system.

B-3: The models:

Models were made at the central workshops in the Ministry of Agriculture and Land Reclamation, to measure the steering angles. Models for the mechanizms were made of wooden bars, for the various geometrical dimensions. They generally conform to as small scale of **1:2**. The model configurations had the variable dimensions shown in Table (1).

Table (1): The variable dimensions of the models.

Configuration No.	Dimensions in mm.					
	W	W/2 or W/3		TR	r	Cotϕ - Cot θ
1	960	W/2	480	912	192	0.39
2	1110		555	1050	222	0.45
3	1260		630	1200	252	0.51
4	1410		705	1340	282	0.58
5	1110	W/3 =370		1050	222	0.45

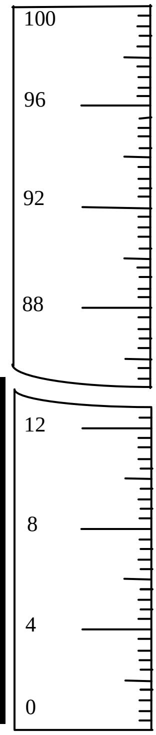

Fig. (3): gauging stick.

Their dimensions consist of fixed dimensions **($Cot\theta = W/WB$, WB=2450,e=70**mm, **r/W=0.2, TR/W=0.95** and **$\gamma_0 = \pi/2 = 90^o$).**

The rest of dimensions are shown in **(**Fig.**5).** A natural-size model was made of steel to Conform with the tractor modifications.

Where: WB=Wheel base, W=Steering pivots distance (1110mm), r=Steering arm length, TR=Tie-rod length, ϕ= Outer front wheel steering angle, θ = Inner front wheel steering angle, e= the distance between tie-rod and hydraulic cylinder base γ_0= Upright angle, equal (π/2).

B-4: Chisel plow:

Mounted type chisel plow of **7** tines arranged in two rows is locally made, Fig**. (4).**

C- Experimental procedures: C-1: Turning time:

The aim of this test was the determination of the average turning time of tractor with each plow by measuring the average cycles of tractor under test. A total of about **10** cycles were made with different speeds suited to field surface conditions. The duration time of each cycle of tractor was recorded to determine the average cycles time, and by estimating the average number of turns for each plow, the average turning time was calculated.

C-2: Plowing time, field capacity and field efficiency:

The purpose of plowing time test was to determine average Tractor operating speed, m/s. In this test, the tractor was loaded by means of plow mounted on the **3-**points linkage. First to fourth gears of tractor were selected to carry out the experiment for chisel plow with the required depth of plowing at an average of **15**cm. A total of six runs were made in this test, one for each gear. The entries within each run were:

(a): The duration time for ten revolutions of each tire of rear wheels.
(b): The distance traveled for ten revolutions of each tire of rear wheels.
(c): Actual plowing width.

Each run (for the same plowing and speed) was replicated **16** times over the test course.

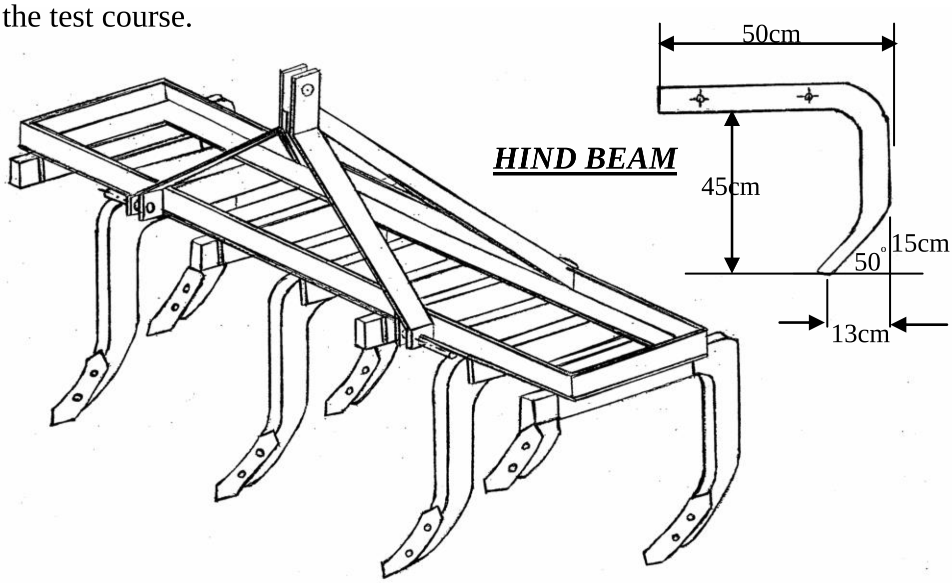

Fig. (4): Local chisel plow (Awady, 2006).

All measurements for each plow on each speed were averaged to determine: **1-** The average plowing tractor speed, m/s. **2-** The average plowing width, cm.

C-3: Determination of fuel consumption:

The aim of this test was to determine fuel consumption of the tractor under test at different values of **W/WB** were used **(0.39, 0.45, 0.51, and 0.58).** Speeds were **(1**st, **2**nd , **3**rd and **4**th gears**).** Four of the soil types were used **(**heavy clay, clay, sandy clay and sandy soil**)** as the average of four replicates during **1st** pass of the ploughing operation for tractor power **65HP (48.2kw).** Fuel consumption per unit time is determined by measuring the volume of fuel consumed during ploughing time. It is measured as follows:

Refueling of tank:

Fuel tank is filled to full capacity before and after the test. Amount of refueling after the test is the fuel consumption during test. A gauging stick is put in fuel tank before and after the test. It reads the fuel before and after the test. Amount of fuel consumption is the difference between them, **(**Fig. **3).**

C-4: The costs:

The aim of this test was to determine the costs of the tractor before and after modification under test at different four values of **W/WB** were used **(0.39, 0.45, 0.51, and 0.58).** Speeds were **(1**st, **2**nd, **3**rd and **4**th gears**).** Four of the soil types were used **(**heavy clay, clay, sandy clay and sandy soil**)** as the average of four replicates during 1st pass of the ploughing operation for tractor power **65HP (48.2kw).** A total of four runs were made in this test, one for each gear of tractor, each run (for the same plow and speed) was replicated 16 times over the test course**,** the tractor or machine operating cost is calculated by using the following equation:

$$C = \frac{P}{H}\left(\frac{1}{Y}+\frac{i}{2}+t+m\right)+(A*K.f.n)+\frac{S}{144} \qquad \textbf{(\textit{Awady, 1998})}$$

where: C: total hourly cost, P: initial price or capital of tractor or machinery, H: estimated yearl-operating hours, y: estimated life-expectancy of machines in years, i: investment or interest rate, t: taxes and overhead rates, m: maintenance and repairs ratio to capital head, K: nominal power in kw or hp, A: ratio of rated power and lubrication related to fuel cost (0.75-0.9), f: specific fuel-consumption in L/kw.h or L/hp.h, according to used units, u: price of fuel per L, S: monthly wages or salaries, and 144: estimated working hours per month.

D- Plowing calculations: **D-1: Plowing time:** a): Average traveling speed of tractor during plowing in meter per second: $V_P = \frac{d_P}{t_P}$

Where: V_P= Average traveling speed of tractor during plowing in m/s, d_P = Average traveling distance for five revolutions of tractor rear tires during plowing in meter, t_P = Average duration time for ten revolutions of tractor rear tires during plowing in second.

b): Effective tractor operating time of plowing, h/fed. $T_e = \frac{4200}{W_{pa} \times V_p \times (60)^2}$

c): Total tractor plowing time **(t),** h/fed. An equation for total tractor plowing time, t, expressed as hours per fadden, is:

$$t = T_e + t_{tu} \quad ; \quad t\% = \frac{t_n}{t_v} \times 100$$

Where: One fadden=4200 m^2, t_n= percentage of total tractor plowing time for measured treatment, t_v= percentage of total tractor plowing time for control treatment, W_{Pa}= Average actual plowing width of plow, equal 1.50 m, T_e= Effective tractor operating time of plowing in h/fed., t_{tu}= Tractor turning operating time at the field ends trough plowing in h/fed., t%= Percentage of total tractor operating time of plowing, %, t=Total tractor plowing time, (h/fed.).

D-2: The field efficiency: a): The theoretical field capacity:

The theoretical field capacity is calculated by using the following formula: $C_{th}=W_{pt}\times V$ (Units should be iromogeneous on both sides).

b): The effective field capacity: $C_{eff} = \frac{1}{T_{eff}}$ (fed./h)

c): The field efficiency: The field efficiency is calculated by using the following formula: $\eta_f = \frac{C_{eff}}{C_{th}} \times 100$ (%)

Where: W_{Pt} = Average theoretical plowing width of plow, equal **1.75**m, **C_{th}=**Theoretical field capacity **(fed./h), C_{eff} =**Effective field capacity **(fed./h), T_{eff} =**Effective total time in required hours per feddan, **η_f** = Field efficiency, **%.**

Fuel consumption:

Fuel consumption per time was determined by measuring the volume of fuel consumed during plowing time. It was calculated by using the following formula: $F.C = \frac{F}{t} \times C$

Where: F.C= Fuel consumption **(L/h), C=**Constant **(3.6), F=** Volume of fuel consumed **(cm^3).**

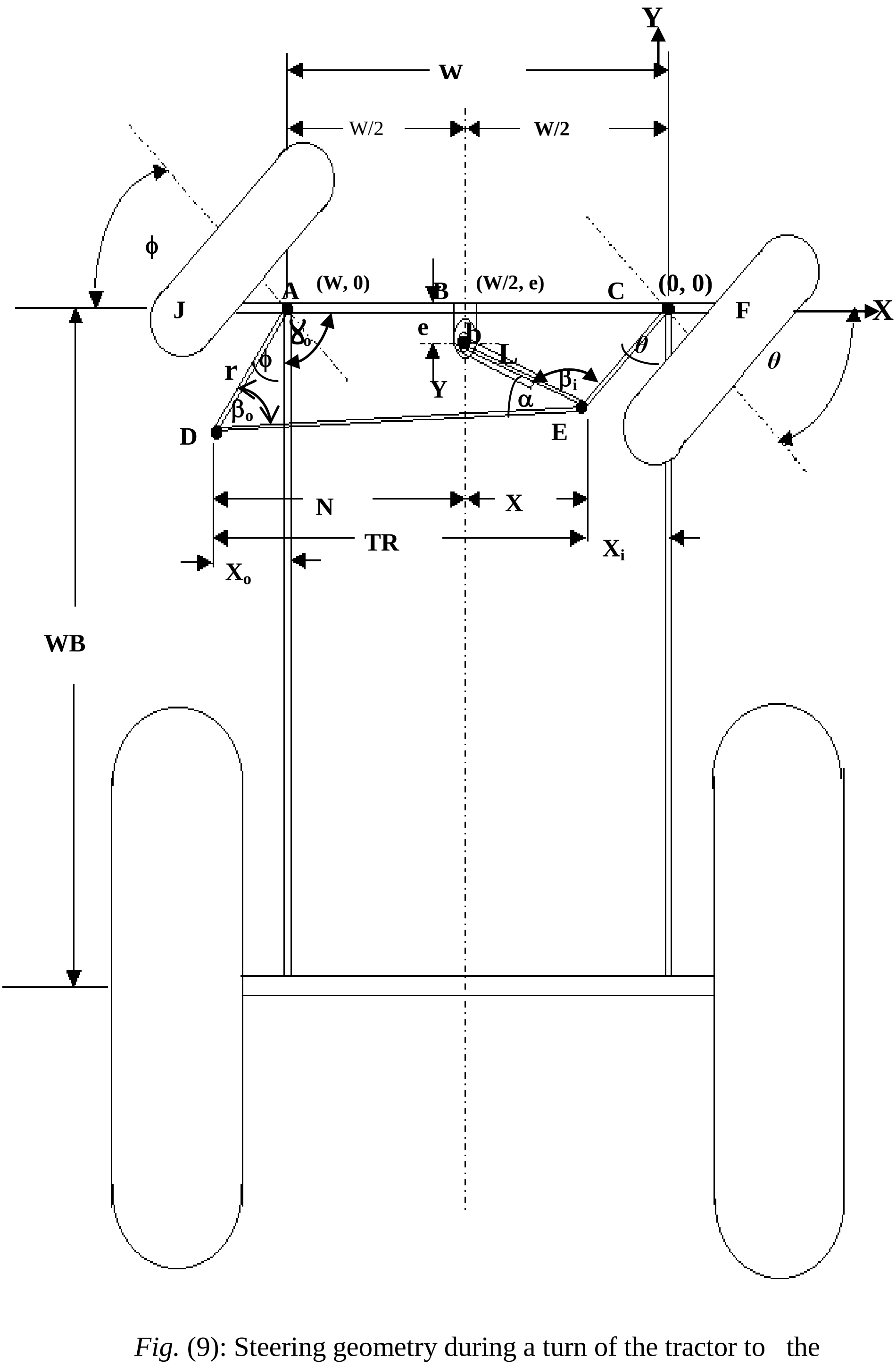

Fig. (9): Steering geometry during a turn of the tractor to the right direction and dimensions of the mechanizm (θ: inner; ϕ : outer steering angles).

RESULTS AND DISCUSSION

The study was carried out to indicate effects of the cylinder length and the tractor dimensions at different geometric proportions on the following factors:

1- Effect of the speed, W/WB on the turning time and total time of plowing:

Figs **(6** and **7),** illustrate the effect of the turning radius, width of field, plowing width of plow, tractor speed on the turning time **(t_{tu})** at different geometric proportions**.** The turning time equations can be derived as follow:

$$\therefore T_C = \frac{\pi R}{V_i} = \frac{\pi(WB)\sqrt{r^2 - \left[TR - \frac{W}{2} - \sqrt{L^2 - Y^2}\right]^2}}{V_i\left(TR - \frac{W(wb)}{WB} - \sqrt{L^2 - Y^2}\right)} \text{ sec.}; \quad t_{tu} = \left(\frac{W_i}{W_{Pa}} - 1\right) \times \frac{\pi R}{V_i} \times \frac{1}{(60)^2} \text{ h/fe.}$$

Where: **t_{tu}:** Tractor turning operating (if square field): time at the field ends though plowing
$$t_{tu} = \left(\frac{\sqrt{4200}}{W_{Pa}} - 1\right) \times \frac{\pi R}{V_i} \times \frac{1}{(60)^2} \quad \text{h/fed.}$$

In h/fed; **W_{pa}**: Plowing width of plow equal **1.5** m; **W_i**: Field width, m; **R**: Turning radius in m; **V_i**: Average idle speed of tractor at the field ends in m/sec.

From Fig. **(6),** it is clear that for all speeds, turning time (t_{tu}) decreased with increasing the soil cohesion. Meanwhile, the total time of plowing (t) increased with the soil cohesion. Values of (t_{tu}), (t) varied from about (0.2909 to 0.2538 h/fed.). Meanwhile, values of (t) (1.6871 to 1.9313 h/fed.) at the soil types varying from about sandy to heavy clay, respectively.

Fig. **(7),** indicates that for all speeds, turning time(t_{tu}), total time of plowing(t) increased with value of W/WB probably due to the increase of steering angle. Values of (t_{tu}) and (t) varied from about (0.2185 to 0.4877 h/fed.); (1.7403 to 2.015 h/fed.) at W/WB varying from about (0.39 to 0.58), respectively.

Also, Figs **(6** and **7**), show that for all soil types, turning time(t_{tu}), the total time of plowing(t) decreased with increasing speed of the tractor. Values of (t_{tu}) and (t) varied from about (0.3744 to 0.14171 h/fed.); (2.486 to 0.9412 h/fed.) at speeds of the tractor varying from about (1st to 4th gears), respectively.

Also, Fig. **(7),** shows that the maximum values of the turning time and total time of plowing (t_{tu}, t) were (0.1145, 0.9152 h/fed.) at speed of the tractor of about (1st gear) for value of W/WB of about 0.58. Meanwhile, the minimum values of (t_{tu}, t) were (0.6742, 2.7858 h/fed.) at the speed of about (4th gear) for value of W/WB of about 0.39, respectively.

2- Effect of the speed, value of W/WB on field capacity and field efficiency From Fig. **(6),** it is clear that for all speeds of the tractor, the effective field capacity (C_{eff}) and the field efficiency (η_f) decreased with the soil cohesion. Values of (C_{eff}) and (η_f) varied from about (0.6786 to 0.5983 fed./h); (69.90 to 64.26%) at the soil types varying from about sandy to heavy clay, respectively.

Figs (6 and 7), show that for all soil types, the effective field capacity (C_{eff}) increased with speed of the tractor. Meanwhile, the field efficiency (η_f) decreased with increasing speed of the tractor. Values of (C_{eff}) varied from about (0.406 to 1.07 fed. /h). Meanwhile, the field efficiency (η_f) varied from about (70.81 to 64.23%) at the speeds varying from about (1st to 4th gears), respectively. Also, Fig. **(7),** shows that for all soil types, the effective field capacity (C_{eff}) and the field efficiency (η_f) decreased with increasing the value of W/WB probably due to the increase of the steering angle. Values of (C_{eff}) and (η_f) varied from about (0.6561 to 0.5692 fed./h); (69.01 to 59.84%) at values of W/WB varying from about (0.39 to 0. 58), respectively. Also, Fig. **(7),** shows that the maximum values of the effective field capacity and the field efficiency(C_{eff}, η_f) were (1.0943 fed./h, 72.58%) at speed of the tractor of about (4th gear) for value of W/WB of about 0.39. Meanwhile, the minimum values of (C_{eff}, η_f) were (0.36 fed/h, 59.84%) at the speed of about (1st gear) for value of W/WB of about 0.58.

3- Effect of the speed and the value of W/WB on the fuel consumption: From Fig. **(6),** it is clear that for all the speeds, the fuel consumption (F.C.) increased with the soil cohesion. Values of (F.C.) varied from about (6.59 to 8.54 L/h); (12.0 to 13.54 L/fed.) at soil varying from about sandy to heavy clay, respectively.

Also, Figs **(6** and **7),** show that for all soil types, the fuel consumption (F.C., L/h) increased with speed of the tractor. Meanwhile, the fuel consumption (F.C., L/fed.) decreased with increasing the speed. Values of the fuel consumption (F.C., L/h) varied from about (6.25 to 9.94 L/h). Meanwhile, values of the fuel consumption (F.C., L/fed.) varied from about (15.47 to 9.31 L/fed.) at speeds of the tractor varying from about (1st to 4th gears), respectively. Fig. **(7),** indicates that for all the speeds, the fuel consumption (F.C.) decreased with increasing the value of W/WB probably due to the increase of the steering angle. Values of (F.C.) varied from about (12.37 to 14.25 L/fed.) at values of W/WB varying from about (0.39 to 0.58), respectively. Also, Fig. **(7),** shows that the maximum value of the fuel consumption was (17.33 L/fed) at speed of the tractor of about (1st gear) for value of W/WB of about 0.58. Meanwhile, the minimum value of the fuel consumption was (9.06 L/fed.) at the speed of about (4th gear) for value of W/WB of about 0.39.

4 - Effect of the speed and the value of W/WB on costs of operation:

From Fig.**(8),** it is clear that for all speeds, costs of operation increased with the soil cohesion. Values of the operation costs varied from about for tractor before modification (18.333 to 19.68 L.E./h); tractor after modification (17.244 to 18.592 L.E./h) at soil types varying from about sandy to heavy clay, respectively.

Figs **(6** through **8),** show that for all the soil types, costs of operation (L.E./h) increased with speed of the tractor. Meanwhile, the costs of operation (L.E./fed.) decreased with increasing speed of the tractor. Values of the operation costs varied from about for tractor before modification (18.1 to 20.642 L.E./h); the tractor after modification (17.01 to 19.554 L.E./h). Meanwhile, values of the operation costs varied from about (43.398 to 18.853 L.E./fed.) at the speeds varying from about (1st to 4th gears), respectively. Fig. **(7),** indicates that for all the speeds, costs of operation increased with value of W/WB probably due to the increase of the steering angle. Values of the operation costs varied from about (30.706 to 35.426 L.E./fed.) at values of W/WB varying from about (0.39 to 0.58), respectively. Also, Fig. **(7),** shows that the maximum value of the operation costs was (47.335 L.E./fed.) at speed of the tractor of about (1st gear) for value of W/WB of about 0.58. Meanwhile, the minimum value of the operation costs was (17.872 L.E./fed.) at the speed of about (4th gear) for value of W/WB of about 0.39.

SUMMARY AND CONCLUSION

The present study was carried out by using two tractors mounted type chisel plough of **7** tines in two rows locally industrial were used, the Belarus tractor, **65B.HP (48.2 kw)** was usage common and widespread under Egyptian conditions. The tractor before, after common and widespread under Egyptian conditions. The tractor before, after modification (this modification allowed tested tractor to decrease the turning radius from **5** to **1.5** m. The experiments of the present study were carried out in the farm of Meet-Yzid village Mania El- Kamh center, Sharkia Governorate, Egypt. The main results obtained from experiments are summarized under the following main points:

1- Effect of the speed, W/WB on the turning time and total time of plowing:

The turning time **(t_{tu})** decreased with the soil cohesion. Meanwhile, the total time of plowing **(t)** increased with the soil cohesion. Values of **(t_{tu})**, **(t)** varied from about **(0.2909** to **0.2538** h/fed.**).** Meanwhile, values of **(t)** **(1.6871** to **1.9313** h/fed.**)** at the soil types varying from about sandy to heavy clay, respectively.

The turning time **(t_{tu})**, total time of plowing **(t)** increased with value of **W/WB**. Values of **(t_{tu})** and **(t)** varied from about **(0.2185** to **0.4877** h/fed.**); (1.7403** to **2.015** h/fed.**)** at **W/WB** varying from about **(0.39** to **0.58),** respectively.

The turning time **(t_{tu})**, the total time of plowing **(t)** decreased with increasing speed of the tractor. Values of **(t_{tu})** and **(t)** varied from about **(0.3744** to **0.14171** h/fed.**); (2.486** to **0.9412** h/fed.**)** at speeds of the tractor varying from about **(1st** to **4th** gears**),** respectively.

2- Effect of the speed, value of W/WB on field capacity and field efficiency:

The effective field capacity **(C_{eff})** and the field efficiency **(η_f)** decreased with the soil cohesion. Values of **(C_{eff})** and **(η_f)** varied from about **(0.6786** to **0.5983** fed./h**); (69.90** to **64.26%)** at the soil types varying from about sandy to heavy clay, respectively.

The effective field capacity **(C_{eff})** increased with speed of the tractor. Meanwhile, the field efficiency **(η_f)** decreased with increasing speed of the tractor. Values of **(C_{eff})** varied from about

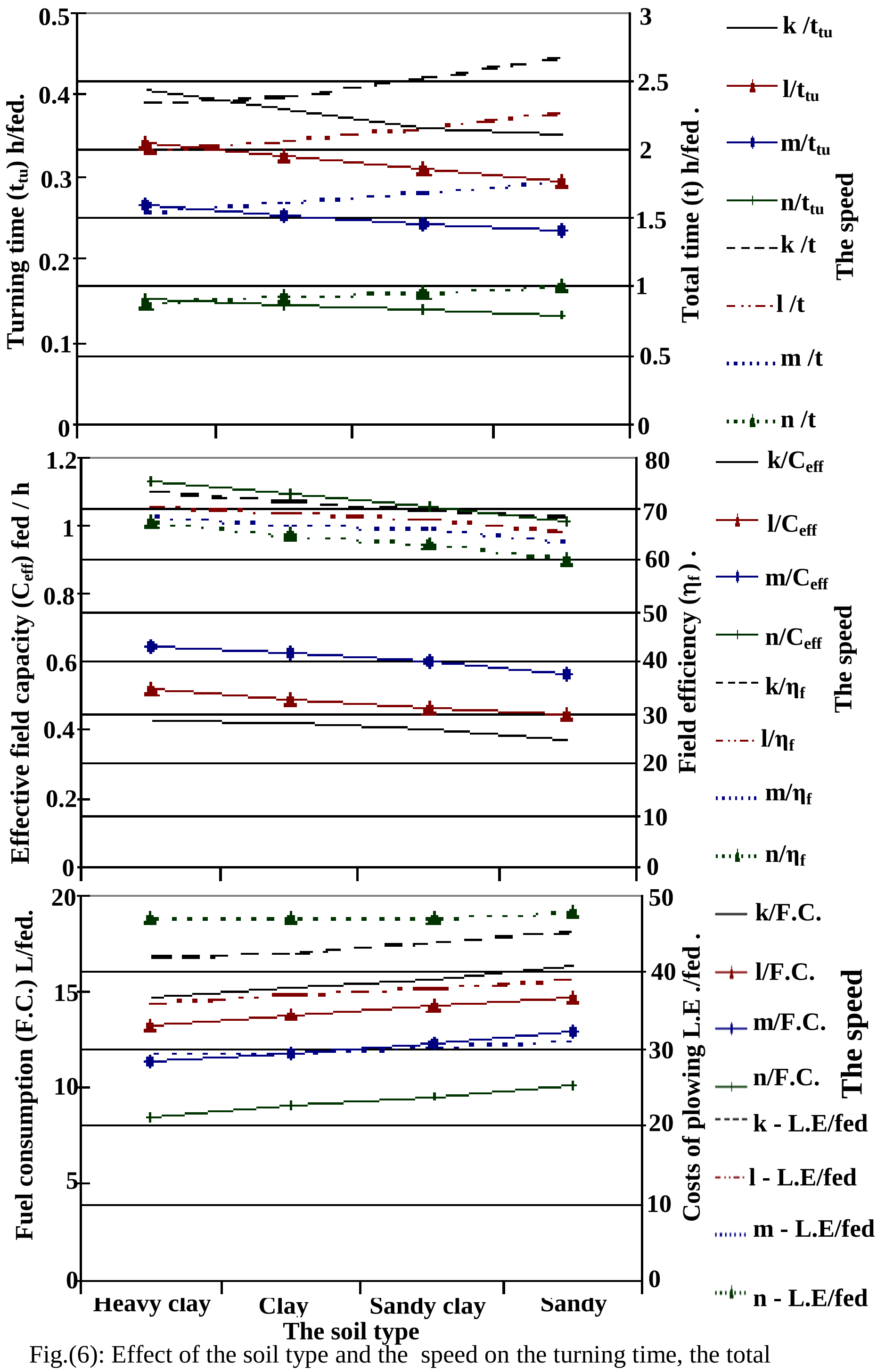

Fig.(6): Effect of the soil type and the speed on the turning time, the total time, the effective field capacity, the field efficiency, the fuel consumption and the costs of plowing.

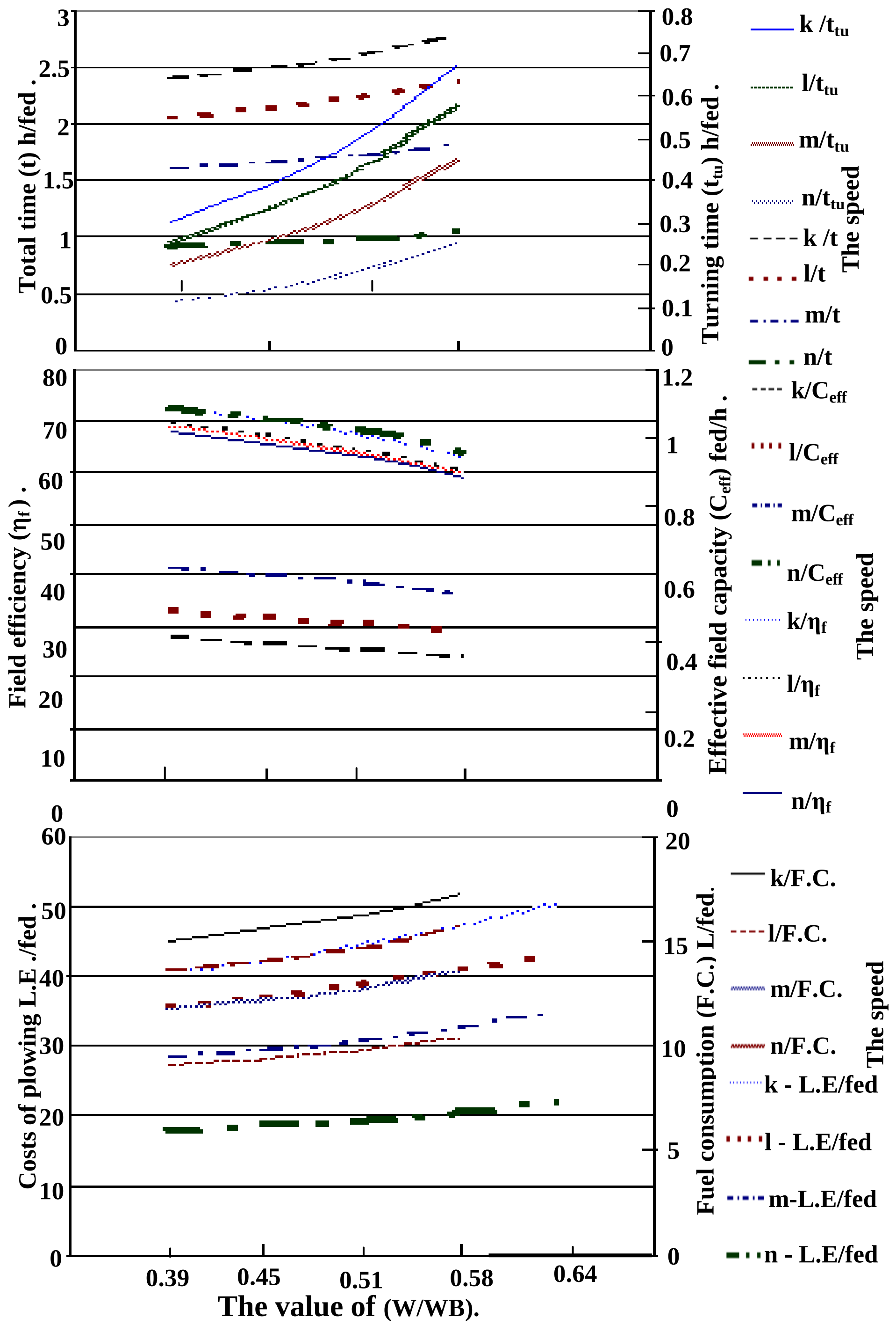

Fig.(7): Effect of the value of (W/WB), the speed on the turning time, the total time, the effective field capacity, the field efficiency, the fuel consumption and the costs of plowing.

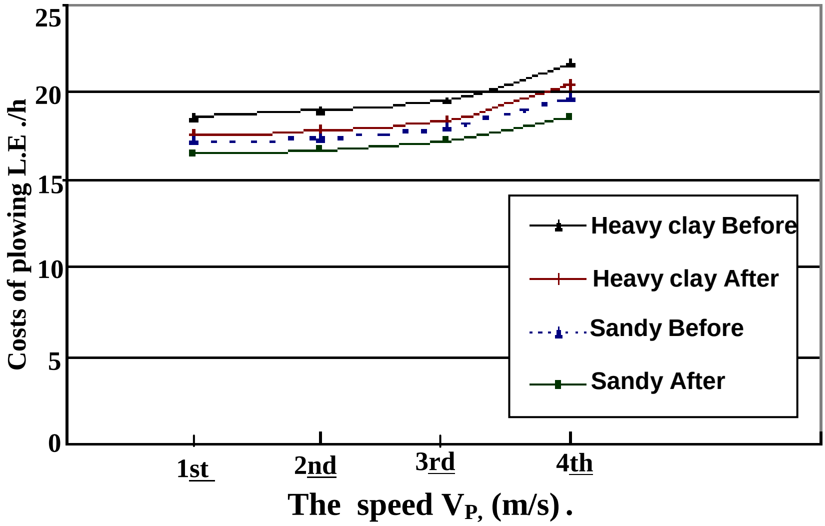

Fig. (8): Effect of the soil type, the speed on costs of plowing for tractor before and after modification.

(0.406 to 1.07 fed./h). Meanwhile, the field efficiency (η_f) varied from about (70.81 to 64.23%) at the speeds varying from about (1st to 4th gears), respectively.

The effective field capacity (C_{eff}) and the field efficiency (η_f) decreased with increasing the value of W/WB. Values of (C_{eff}) and (η_f) varied from about (0.6561 to 0.5692 fed./h); (69.01 to 59.84%) at values of W/WB varying from about (0.39 to 0. 58), respectively.

3- Effect of the speed and the value of W/WB on the fuel consumption:

The fuel consumption (F.C.) increased with the soil cohesion. Values of (F.C.) varied from about (6.59 to 8.54 L/h); (12.0 to 13.54 L/fed.) at soil varying from about sandy to heavy clay, respectively. The fuel consumption (F.C., L/h) increased with speed of the tractor. Meanwhile, the fuel consumption (F.C., L/fed.) decreased with increasing the speed. Values fuel consumption (F.C., L/h) varied from about (6.25 to 9.94 L/h). Meanwhile, fuel consumption (F.C., L/fed.) varied from about (15.47 to 9.31 L/fed.) at speeds of the tractor varying from about (1st to 4th gears), respectively. The fuel consumption (F.C.) decreased with increasing the value of W/WB. Values of (F.C.) varied from about (12.37 to 14.25 L/fed.) at values of W/WB varying from about (0.39 to 0.58), respectively.

4 - Effect of the speed and the value of W/WB on costs of operation:

Costs of operation increased with the soil cohesion. Values of costs of operation varied from about for tractor before modification (18.333 to 19.68 L.E./h); tractor after modification (17.244 to 18.592 L.E./h) at soil types varying from about sandy to heavy clay, respectively. Costs of operation (L.E./h) increased with speed of the tractor. Meanwhile, costs of operation (L.E./fed.) decreased with increasing speed of the tractor. Values of costs of operation varied from about for tractor before modification (18.1 to 20.642 L.E./h); the tractor after modification (17.01 to 19.554 L.E./h). Meanwhile, values of costs of operation varied from about (43.398 to 18.853 L.E./fed.) at the speeds varying from about (1st to 4th gears), respectively.

Costs of operation increased with value of W/WB. Values of costs of operation varied from about (30.706 to 35.426 L.E./fed.) at values of W/WB varying from about (0.39 to 0.58), respectively.

REFERENCES

Awady, M.N. (1998). "Engineering of tractors and agricultural machinery." textbk.,Col. Ag., A. Shams Univ., 5th. ed., :167-164. (In Arabic, updating 1998).

Awady, M. N., (2006). **"**Engineering of agricultural Machinery." Col. Ag., A. Shams U., Textbook in Arabic**:**

EL-Sayed G.H. and R., M.M. EL-Kilani. (2002). "Predicted vs. measured tractor fuel-consumption in soil-working operations." Misr J. Ag. Eng., 19(1):268-284.

Gurevich, A.; and Sorokin, E. (1976). "Tractors." Mir. Pub., Moscow:

Hamad, S.A.; H.N. Abdel-Mageed; and S.El-Kawaga (1992). "Effect of tillage methods on soil physical characteristics and corn yield." Misr J. Ag. Eng., 23(6):1466-1470.

Hindey, F.I; Helmy, M.A.; and Z.M. Imara (1998). "Technology of tillage by using a combined unit and its effect on soil conditions, plowing quality field performance and crop response." Misr. J. Ag. Eng., 15(1): 106-132.

Kamel, M.M. (1987). “Selecting the optimum sized tractor.” M. Sc/Th., Fac. of Agric., Ain Shams Univ., Egypt: 86-89 .

Katary, H.S. (1976). “A study on some specifications of tractor most suitable for Egyptian conditions.” M.Sc. Th. Fac. of Agric., El-Azhar Univ., Cairo, Egypt: 118-123.

Liljedahl, J.B.; R. Gluck; and M.E. Schroeder (1959). “Steering-force requirements of wheel tractors.” Ag. Eng., Sept., : 522-525.

Nasr, H.M.; Nasr, G. E.M.; and Imbabi, A.T. (1998). “Mechanization of seedbed preparation for sunflower.” Misr J.A. Eng., 15(2): 225--245.

Novikov, GV. (1991). “Communication systems of tractors with micro-processor automation.” Traktory-i-sei’ skokhozyaistvennye-Mashiny. No. 6: 47-49.

الملخص العربى

دراسة على كفاءة أجهزة توجيه الجرارات الزراعية

٥- الاختبارات الحقلية (السعة ,الكفاءة الحقلية والتكاليف)

أبوالخير مصطفى محمد سرحان* حسني سلطان القطري محمد نبيل العوضي *****

تهدف هذه الدراسة إلى معرفة النظام الأمثل لتشغيل وصيانة الجرار الزراعي بصفة عامة والتوجيه والقيادة بصفة خاصة وبالتالي تصميم جهاز توجيه آلي يتم تشغيله بطريقة هيدروليكية بحيث تعمل كوحدة مجمعة تحت جميع خطوات التشغيل ونقل الحركة إلى عجلتي الأرض الأماميتين لتكون ذاتية التوجيه وذلك في الجرار الزراعي.

ولتحقيق هذا الهدف تم اختيار جرارين من نفس النوع ومحراث ٧ سلاح صناعة محلية والجرار المستخدم ماركة بيلاروس **(10M3-6KM)** ذات قدرة متوسطة متعدد الأغراض ٦٥ حصان ميكانيكي(٤٨,٢ كيلووات) شائع الاستخدام تحت الظروف المصرية وأختبر ليناسب الفلاح المصري والمزارع المصرية وأستعمل الجرار قبل وبعد التعديل(وهذا التعديل يسمح بتقليل نصف قطر الدوران من ٥ إلى ١,٥متر) وقد أجريت التجارب الحقلية لهذه الدراسة في مزرعة بقرية ميت يزيد مركز منيا القمح محافظة الشرقية. ويمكن تلخيص أهم النتائج المتحصل عليها فيما يلي:

٥- تأثير السرعة وقيمW/WB على زمن الدورانات وزمن الحرث:

١- زمن الدورانات يقل بزيادة تماسك التربة وبينما زمن الحرث يزداد بزيادة قوام التربة وقيم زمن الدورانات يتراوح بين(٠,٢٩٠٩-٠,٢٥٣٨ ساعة/فدان) وزمن الحرث الكلى يتراوح بين (١,٦٨٧١-١,٩٣١٣ساعة/فدان)عند أنواع تربة تتراوح بين:رملية وطينية ثقيلة على الترتيب.

*طالب دراسات عليا, درجة الدكتوراه, ق. هـ. ز. ـ ك. ز. ـ ج. الأزهر .
**أستاذ الهندسة الزراعية- هـ. ز. ـ ك. ز. ـ ج. الأزهر .
***أستاذ متفرغ ـ هـ. ز. ـ ك. ز. ـ ج. عين شمس .

٢- زمن الدورانات وزمن الحرث الكلى يزداد بزيادة **W/WB** وقيمتهما تتراوح بين(٠,٢١٨٥-٠,٤٨٧٧ساعة/فدان)، (٢,٠١٥-١,٧٤٠٣ساعة/فدان) عند قيم **W/WB** تتراوح بين (٠,٣٩-٠,٥٨)على الترتيب.

٣- زمن الدورانات وزمن الحرث الكلى يقل بزيادة سرعة الجرار وقيمتهما تتراوح بين(٠,٣٧٤٤-٠,١٤١٧١ساعة/فدان)،(٢,٤٨٦-٢,٩٤١٢ساعة/فدان)عند سر عات تتراوح بين(الأولى والرابعة)على الترتيب.

٢- تأثير السرعة وقيم W/WB على السعة والكفاءة الحقلية:

١- السعة والكفاءة الحقلية تقل بزيادة تماسك التربة وقيم السعة الحقلية تتراوح بين(٠,٦٧٨٦-٠,٥٩٨٣فدان/ساعة) وقيم الكفاءة بين(٦٩,٩-٦٤,٢٦%)عند أنواع تربة تتراوح بين:رملية وطينية ثقيلة على الترتيب.

٢- السعة الحقلية تزداد وبينما الكفاءة الحقلية تقل بزيادة سرعة الجرار وقيم السعة تتراوح بين(٠,٤٠٦-١,٠٧فدان/ساعة) وقيم الكفاءة تتراوح بين(٧٠,٨١-٦٤,٢٣%)عند سر عات تتراوح بين(الأولى والرابعة) على الترتيب.

٢- السعة والكفاءة الحقلية تقل بزيادة **W/WB** وقيمهما تتراوح بين(٠,٦٥٦١-٠,٥٦٩٢فدان/ساعة) وقيم الكفاءة الحقلية تتراوح بين(٦٩,٠١- ٥٩,٨٤%)عند قيم **W/WB** تتراوح بين(٠,٣٩-٠,٥٨)على الترتيب.

٣- تأثير السرعة وقيمW/WBعلى استهلاك الوقود :

١- استهلاك الوقود يزداد بزيادة تماسك التربة وقيمته تتراوح بين(٦,٥٩-٨,٥٤لتر/ساعة)،(١٢,٠-١٣,٥٤لتر/فدان)عند أنواع تربة تتراوح بين:رملية وطينية ثقيلة على الترتيب.

٢- استهلاك الوقود يزداد بزيادة السرعة وقيمته تتراوح بين (٦,٢٥-٩,٩٤لتر/ساعة)وبينما يقل الاستهلاك بالنسبة للفدان وقيمته تتراوح بين (١٥,٤٧-٩,٣١لتر/فدان)عند سر عات تتراوح بين (الأولى والرابعة)على الترتيب.

٣- استهلاك الوقود يزيد بزيادة **W/WB** وقيمته تتراوح بين(١٢,٣٧- ١٤,٢٥لتر/فدان)عند قيم **W/WB** تتراوح بين (٠,٣٩- ٠,٥٨)على الترتيب.

٤- تأثير السرعة وقيمW/WB على تكاليف الحرث:

١- تكاليف الحرث تزداد بزيادة تماسك التربة عند سرعة الجرار وقيم تكاليف الحرث لكلا من الجرار قبل التعديل تتراوح بين(١٨,٣٣٣-١٩,٩٨جنية/ساعة)وللجرار بعد التعديل بين(١٧,٢٤٤-١٨,٥٩٢جنية/ساعة) وقيم تكاليف الحرث تتراوح بين(٣١,٥٨-٣٣,٧٠٣جنية/فدان)عند أنواع تربة تتراوح بين:رملية وطينية ثقيلة على الترتيب.

٢- تكاليف الحرث تزيد بزيادة سرعة الجرار وقيمتها لكلا من الجرار قبل التعديل(١٨,٨١-٢٠,٦٤٢جنية/ساعة)وللجرار بعد التعديل(١٧,٠١-١٩,٥٥٤جنية/ساعة)وقيمتها تتراوح بين(٤٣,٣٩٨-١٨,٨٥٣جنية/فدان) عند سر عات تتراوح بين(الأولى والرابعة)على الترتيب.

٣- تكاليف الحرث تزيد بزيادة قيم **W/WB** وقيمتها تتراوح بين(٣٠,٧٠٦-٣٥,٤٢٦جنية/فدان) عند قيم **W/WB** تتراوح بين (٠,٣٩- ٠,٥٨)على الترتيب.