University of Khartoum

Faculty of Engineering

Department of Agricultural Engineering

Evaluation of Some Standards for Tillage Implement's Draft Requirements in Soba Area , Khartoum State , Sudan.

Mai Muzamel Ahmed

B.Sc. (Honors) in Agricultural Engineering

University of Juba (2004)

A thesis

Submitted to the University of Khartoum in Partial fulfillment of the requirement for M. Sc. Agricultural Engineering

Supervisor: Dr. Al Hag Adam Yousif

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Compartive Study between calculated & measured conditions parameters under field

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Dedication

To my beloved mother who stands to my side giving me the hope to go on and to be who I am now.

To my sisters & husband for being good supporters in my life..

To my light's life ... my son ... Awab& Gassan.

Thanks ....

Acknowledgment

To all staff members

Dr. Elhag Adam Yousif who helped me a lot giving me

a lot of his presious ... time

All staff in agricultural engineering department –

Faculty of Engineering.....

To all staff of the farm of the agricultural Engineering

Department in Soba..

Thanks ...

ملخص البحث

هذه الدراسة تهدف إلى المقارنة ما بين بعض القيم التي حسبت بواسطة الجمعية الأمريكية للمهندسين الزراعيين والحيويين مثل الكفاءة الحقلية والسعة الحقلية وقوة السحب وقدرة قضيب الجر والانزلاق لأنواع مختلفة من الآليات تعمل في أنواع مختلفة من التربة.

وقد تمت هذه المقارنة عن طريق إجراء تجارب حقلية في مزرعة قسم الهندسة الزراعية سوبا لثلاثة أنواع من الآليات وهي المحراث القرصي والطراد والكسارة عند سرعات وأعماق مختلفة.

وبذلك تم الحصول على قيم مقاسه لقوة السحب وقدرة قضيب الجر باستخدام جهاز قياس قوة السحب وقدرة قضيب الجر ومن ثم مقارنتها بالقيم المحسوبة بالمعادلات عن نفس الأعماق والسرعات المستخدمة في التجارب الحقلية.

وأيضاً تم حساب قيم الانزلاق لنوعين من الجرارات لتربة محروثة وذلك في مزرعة وزارة الزراعة والغابات بسوبا.

أما الكفاءة الحقلية فقد تم حسابها لنفس الآليات السابق ذكرها، وذلك عن طريق حساب الزمن الكلي والزمن المفقود والعمق الحقيقي والعمق المقاس وكذلك حساب السرعة الحقيقية والسرعة المتأثرة بواسطة عامل الانزلاق ومن ثم حسابها بالمعادلات ومقارنتها مع قيمة الكفاءة الحقلية الموضوعة بواسطة جداول الجمعية الهندسية الأمريكية عند نفس السرعة.

وتشير النتائج إلى وجود تطابق تقريبي للقيم المقاسة والقيم المحسوبة بواسطة المعادلات والجداول الموضوعة بواسطة الجمعية الأمريكية لقوة السحب وقدرة قضيب الجر وتتراوح نسبة الخطأ بالنسبة للكسارة ما بين 22%-66% وما بين 38% -55% للمحراث القرصي أما بالنسبة للطراد فهي ما بين 7.5% - 30%.

أما بالنسبة للكفاءة الحقلية فتشير النتائج إلى انخفاضها بالنسبة للكفاءة الحقلية الموضوعة بواسطة جداول الجمعية الهندسية الأمريكية.

Abstract

The objective of this study is to evaluate some ASABE standards under real working conditions for different soils, implements, and tractors and then to compare these values measured on the field with those calculated by using ASABE 497 equations.

Many experiments were carried out in the Agricultural engineering department farm at Soba. Three types of implements (disc plow, ridger, rotovator) with different speeds and different operating depths were used.

The values for draft were measured by using a draw bar dynamometer, and the slip was measured by using two tractors with different loading conditions.

The values of field efficiency were measured by calculating the total time, the time loss during the operation, the real width, implement working width and the speed.

The study showed that:

- The measured draft and drawbar power values were found to be matching with the calculated values using ASABE equations and the error range from 22 to 66% for Rotovator, 38 to 55% for disc plow and 7.5 to 30 % for the ridger.
- The values of slip for two types of tractors on (tilled soil) was found within the range of ASABE standards values.
- The field efficiencies measured in the field for three implements (19% for ridger,23.6% for disc plow,51.9% for rotary hoe) were lower than the standard values(70%-85%).

Chapter (1)

Introduction

1-1 Background:

Tillage may be defined as the mechanical manipulation of soil for nutring crops.

The objectives of tillage are:

- To prepare a desirable seedbed or root bed.
- To control weeds and remove unwanted crop plant.
- To minimize soil erosion.
- To establish specific surface configuration for planting, irrigation, drainage or harvesting operation .
- To incorporate and mix fertilizer, manure, pesticides.

There are two types of tillage:

1-1-1 Primary Tillage:

It is the first operation to be carried out for breaking soil surface Implements used for primary tillage are:

- Moldboard plows.
- Disc plows.
- Chisel plows.
- Subsoiler.
- Heavy disc harrow.
- Rotary tiller and bedders.

1-1-2 Secondary Tillage:

Any tillage operation performed after the primary tillage is called secondary tillage. The main objective of secondary tillage is to break down large clods and to prepare an ideal seedbed for planting.

Implements used in secondary tillage are:

- Disc harrows.
- Cultivators.
- Ridgers.
- Rotary hoes and rotary cultivaters.
- Tandem and offset disc harrows.

A tillage tool is defined as an individual soil engaging element. A tillage implement consist of a single tool or a group of tools, together with associated frame, wheel, hitch, control and protection devices, and any power transmission component.

The performance of the tillage tools is determined by their draft and power requirement's and the quality of work.

The definition of quality of work depends upon the type of tillage tool; no universally accepted method has been developed to quantity of the work. Therefore, only the draft force acting on tillage tools and their power requirements are presented here;

The effects of soil and tool parameters as well as operations conditions on draft force and power requirements are discussed in this study.

Tillage cost represents the largest proportion of agricultural production cost. Therefore, any effort exerted to reduce the draft of tillage implements will automatically reduce the energy required and hence will reduce the overall production cost. This study will focus on some parameters which affect the draft of tillage tools.

1-2 Objectives:

The objectives of this study are:

- Field evaluation of some parameters (constants) used in ASABE standard's for calculating (draft, drawbar power, slip, field efficiency) under different working conditions in Sudan.
- Comparison between the results (values measured in the field) and those calculated by using the equations and tables developed by ASABE 497.

Chapter (II)

Literature Review

Previous Studies

2-1 Spread sheet of matching tractor and implement:

(Robert grisso *et al*., 2006) suggested spread sheets for matching tractors and implements.

The objective of the study was to demonstrate the use of spread sheet for matching tractor and implement.

It included three tractors of different power levels and configuration and three different implements and two different soils types, they obtained the following results (table 2.1)

[Table (2.1)]: Result of analysis for matching implement with tractor

Implement	Soil factor	Depth (mm)	Width (m)	Speed (km/hr)	Draft (kw)	D.B.P (Kw)	P.P.T.O (kw)	Field capacity (ha/hr)
Moldboard plow	1	203	1.8	8	36.4	81	108	1.25
	3	203	10.8	8	16.4	37	49	1.25
Disc harrow tandem	1	152	6.4	8	42.6	95	127	4.38
	3	152	6.4	8	33.2	74	99	4.38
Field cultivator	1	127	5.5	8	23.1	52	69	3.75
	3	127	5.5	8	15.0	45	45	3.72

2-2 Matching tractor power and implement size:

(William Edwards) in (May 2007) also conducted a research work aiming to determine the power requirements for different implement sizes.He concluded that the power needed to pull a certain implement depends on the width of the implement, the ground speed, draft requirement and soil conditions, and obtained the following results table (2.2).

[Table (2.2)]: Draft requirement for various implement

Equipment name	**Speed (mph)**	**Draft [average] (lb. per unit of width)**	**Draft [range] (lb. per unit of width)**
Tillage			
Moldboard plow (16 in. bottom,17in. deep)			
Light soil	5.0	320	220-430 per foot
Medium soil	4.5	500	350-650 per foot
Heavy soil	4.5	800	580-1,140 per foot
Clay soil	4.0	1200	1,000-1,400 per foot
Chisel – Plow			
(7-9 in. deep)	5.0	500	200-800 per foot
Disk			
Single gang	5.5	75	50-100 per foot
Tandem	5.5	200	100-300 per foot
Heavy or offset	5.0	325	250-400 per foot
Field cultivator	5.0	300	200-400 per foot
Spring-tooth harrow	5.0	200	70-300 per foot
Spike- tooth harrow	6.0	50	20-60 per foot

Roller packer	5.0	100	20-150 per foot
Cultivator			
Field (3-5 in deep)	5.0	250	60-300 per foot
Row crop	4.5	80	40-120 per foot
Rotary hoe	7.5	84	30-100 per foot
Sub soiler (16 in deep)			
Light soil	4.5	1500	1,100-1,800 per tooth
Medium soil	4.5	2000	1,600-2,600 per tooth
Heavy soil	4.5	2600	2,000-3,000 per tooth
Planting			
Planter only	5.0	150	100-180 per row
Planter with attachment	5.0	350	250-400 per row
Grain drill	5.0	70	30-100 per row
No-till drill	5.0	200	160-240 per row
Applying chemicals			
An hydrousammonia applic	4.5	425	375-450 per shank

2-3 The validity of application of the draft equation developed by ASABE in Sudan.

With the objective of considering the validity of application of equations developed by the ASABE in standard (D 497) in Sudan,(Rayan Hassan Mohammed, Sarah Adam Salih) in (May 2008), carried out field experiments with two types of machines namely (Ridger & Disc Plow) and two tractors with the same type and using different speeds and operating depths.

The study showed that in general the measured draft and drawbar power values are not matching with the calculated values using ASABE equations.

[Table (2.3.a)] The comparison between the values measured and the values calculated by ASABE equation (ridger)

Width (m)	Depth (cm)	Speed (Km/hr)	Calculated draft (KN)	Measured draft (KN)	Calculated P_{db} (KW)	Measured P_{db} (KW)
1.81	10	4	5,482,49	4,517.20	6,091.65	5,019.11
1.81	10	6	5,929,56	4,780,31	9,882,60	7,967.18
1.81	10	8	6,376,63	5,192,04	14,170,28	11,537.86
1.81	20	4	10,964.98	7,560.90	12,183.31	8,401.00
1.81	20	6	11,859.12	10,755.10	19,765.20	17,925.16
1.81	20	8	12,753.26	11,703.62	28,340.57	26,008.04
1.81	30	4	16,447.47	13,340.00	18,274.96	14,822.22
1.81	30	6	17,788.68	15,605.65	29,647.80	26,009.42
1.81	30	8	19,129.89	18,087.97	42,150.86	40,195.49

[Table (2.3.b)] The results for (DISC plow)

Width (m)	Depth (cm)	Speed (Km/hr)	Calculated draft (KN)	Measured draft (KN)	Calculated P_{db} (KW)	Measured P_{db} (KW)
1.81	10	4	3,631.32	8,189.98	4,034.80	9,099.97
1.81	10	6	4,136.22	8,423.55	6,893.70	14,039.24
1.81	10	8	4,843.08	8,766.12	10,762.40	19,480.26
1.81	20	4	7,262.64	9,435.85	8,069.60	10,484.27
1.81	20	6	8,272.44	11,202.04	13,787.40	18,670.06
1.81	20	8	9,689.16	11,739.63	21,524.80	26,088.06
1.81	30	4	10,893.96	10,984.75	12,104.40	12,205.27
1.81	30	6	12,408.66	13,520.44	20,681.10	22,534.06
1.81	30	8	14,529.24	14,756.79	32,287.20	32,792.86

2-4 Draft and power requirement:

The primary purpose of agricultural tractors, especially those in the middle to high power ranges is to perform draw bar work, the value of the tractor is measured by the amount of work accomplished relative to the cost incurred in getting the work done/ drawbar work is defined by pull and travel speed, there fore the idle tractor converts all the energy from fuel into useful work at the drawbar in practice most of the potential energy is lost in the conversion of chemical energy to mechanical energy.

2-4-1 Draft:

Is defined as the component of tractor pull acting in the plow parallel to the line of travel,

2-4-2 Factors affecting the draft:

A) Soil types :

Are the most important factors affecting variation of the draft, when the moisture content increases, the draft will be increased up to the plasticity range, in sandy soil the draft increases and in clay soil the draft decreases.

B) The soil condition:

- A dry soil requires excessive power and also accelerates wear of cutting edges.
- The degree of soil compaction and the absence of cover crops increase the draft.
- In fine soil texture the draft is high, but in coarse textured soils draft is low.

C) Tillage depth:

Depth of operation is directly proportional to the draft.

D) Forward speed:

Speed is directly proportional to the draft, when the speed increases the draft also increases.

E) Design Factor and shape of the Implements:

2-4-3 Calculation of draft and power:

The American society of Agricultural & Biological Engineers (ASABE) in (Feb 2006) issued the standard (497), for estimating the draft requirements for different implements at different working condition as follows:

$D = F_i [A + B (S) + C (S^2)] wd$

Where:

D = implement draft (N), (Ib)

F = adimension less soil texture adjustment parameter

i = I for fine, 2 for medium and 3 for coarse texture

A, B & C = machine specific parameters [table (2.4.1)]

S = field speed (km/hr), (mil /hr)

W = machine working width, (m), (ft)

d = tillage depth (cm), (in).

[Table (2.4.1)] Draft parameter for tillage and seeding implement

Implement	Width units	A	B	C	F_1	F_2	F_3	Range ±%
Major tillage tools								
Subsoiler/ manure injector								
Narrow point	Tools	226	0.0	1.8	1.0	0.70	0.45	50
30 cm winged point	Tools	294	0.0	2.4	1.0	0.70	0.45	50
Moldboard plow	m	652	0.0	5.1	1.0	0.70	0.45	40
Chisel plow								
5 cm straight point	tools	91	5.4	0.0	1.0	0.85	0.65	50
7.5 cm shovel / 35 cm	tools	107	6.3	0.0	1.0	0.85	0.65	50

Sweep									
10 cm twisted shovel	tools	123	7.3	0.0	1.0	0.85	0.65	50	
Sweep plow									
Primary tillage	m	390	19.0	0.0	1.0	0.88	0.65	45	
Secondary tillage	m	273	13.3	0.0	1.0	0.88	0.65	35	
Disc harrow, tandem									
Primary tillage	m	309	16.0	0.0	1.0	0.88	0.78	50	
Secondary tillage	m	216	11.2	0.0	1.0	0.88	0.78	30	
Disc harrow, offset									
Primary tillage	m	364	18.8	0.0	1.0	0.88	0.78	50	
Secondary tillage	m	254	13.2	0.0	1.0	0.88	0.78	30	
Disc gang, single									
Primary tillage	m	124	6.4	0.0	1.0	0.88	0.78	25	
Secondary tillage	m	86	4.5	0.0	1.0	0.88	0.78	20	
Coulters									
Smooth or ripple	tools	55	27	0.0	1.0	0.88	0.78	25	
Bubble or flute	tools	66	3.3	0.0	1.0	0.88	0.65	25	
Field cultivator									
Primary tillage	tools	46	28	0.0	1.0	0.85	0.65	30	
Secondary tillage	tools	32	1.9	0.0	1.0	0.85	0.65	25	
Row crop cultivator									
S – tine	rows	140	7.0	0.0	1.0	0.85	0.65	15	
C – Shank	rows	260	13.0	0.0	1.0	0.85	0.65	15	
No – till	rows	260	13.0	0.0	1.0	0.85	0.65	15	
Rod weeder	m	210	10.7	0.0	1.0	0.85	0.6	25	

Disc bedder	rows	185	9.5	0.0	1.0	0.88	0.78	40
Minor Tillage tools								
Rotary hoe	m	600	0.0	0.0	1.0	1.0	1.0	30
Coil tine harrow	m	250	0.0	0.0	1.0	1.0	1.0	20
Spike tooth harrow	m	600	0.0	0.0	1.0	1.0	1.0	30
Spring tooth harrow	m	2000	0.0	0.0	1.0	1.0	1.0	35
Roller packer	m	600	0.0	0.0	1.0	1.0	1.0	50
Roller harrow	m	2600	0.0	0.0	1.0	1.0	1.0	50
Land plane	m	8000	0.0	0.0	1.0	1.0	1.0	45
Seeding implements								
Row crop planter, prepared								
Seedbed								
Mounted								
Seeding only	rows	500	0.0	0.0	1.0	1.0	1.0	25
Drawn								
Seeding only	rows	900	0.0	0.0	1.0	1.0	1.0	25
Seed, fertilizer, herbicides	rows	1.550	0.0	0.0	1.0	1.0	1.0	25
Row crop planter, no-till								
Seed, fertilizer, herbicides								
1 fluted Coulter per row	rows	1,820	0.0	0.0	1.0	0.96	0.92	25
Seed, fertilizer, herbicides								
3 fluted coulters per row	rows	3,400	0.0	0.0	1.0	0.94	0.82	35
Grain drill w/ press wheels								
<2.4m drill width	rows	400	0.0	0.0	1.0	1.0	1.0	25

2.4 to 3.7m drill width	rows	300	0.0	0.0	1.0	1.0	1.0	25
> 3.7 m drill width	rows	200	0.0	0.0	1.0	1.0	1.0	25
Grain drill, no – till								
1 fluted coulter per row	rows	720	0.0	0.0	1.0	0.92	0.79	35
Hoe drill								
primary tillage	m	6,100	0.0	0.0	1.0	1.0	1.0	50
Secondary tillage	m	2,900	0.0	0.0	1.0	1.0	1.0	50
Pneumatic drill	m	3,700	0.0	0.0	1.0	1.0	1.0	50

Drawbar power

$P_{db} = \frac{D*S}{3.6}$

Where

P_{db} = drawbar power (kw)

D = Implement draft (KN)

S = travel speed (km/ hr)

- Power take off (PTO power)

$P_{PTO} = a + bw + CC_{mt}$

Where

P_{PTO} = PTo power (kw)

a, b, c = machine specific constant in table (2.4.2)

W = width of machine (m)

C_{mt} = theoretical field capacity on amalerial basis (kg/ha).

[Table (2.4.2)] Rotary power requirements

Machine type	**a (kw)**	**b (kw/m)**	**c (kw/)**	**Range ± %**
Baler, small rectangular	2.0	0	1.0	35
Baler, large rectangular bales	4.0	0	1.3	35
Baler, large round (var. chamber)	4.0	0	1.1	50
Baler, large round (fixed chamber)	2.5	0	1.8	50
Beet harvester	0	4.2	0	50
Beet topper	0	7.3	0	30
Combine, small rains	20.0	0	3.6	50
Combine, corn	35.0	0	1.6	30
Cotton picker	0	9.3	0	20
Cotton stripper	0	1.9	0	20
Feed mixer	0	0	2.3	50
Forage blower	0	0	0.9	20
Flail harvester, direct – cut	10.0	0	1.1	40
Forage harvester, corn silage	6.0	0	3.3	40
Forge harvester, wilted alfalfa	6.0	0	4.0	40
Forage harvester, direct cut	6.0	0	5.7	40
Forage wagon	0	0	0.3	40
Grinder mixer	0	0	4.0	50
Manure spreader	0	0	0.2	50
Mower, cutter bar	0	1.2	0	25
Mower, disc	0	5.0	0	30

Mower, flail	0	10.0	0	40
Mower- conditioner, cutter bar	0	4.5	0	30
Mower – conditioner, disc	0	8.0	0	30
Potato harvester	0	10.7	0	30
Potato windrower	0	5.1	0	30
Rake, side delivery	0	0.4	0	50
Pake, rotary	0	2.0	0	50
Tedder	0	1.5	0	50
Tub grinder, straw	5.0	0	8.4	50
Tub grinder, alfalfa hay	5.0	0	3.8	50
Windrowe / swather, small grain	0	1.3	0	40

2-5 Field Capacity and Field efficiency:

2-5-1 Field capacity:

Field capacity refers to the amount of area processing that a machine can accomplish per hour of time, field capacity can be expressed on a material or area basis. On a area basis the field capacity is

$C_a = \frac{VW\eta}{10}$

On a material basis, the field capacity is:

$C_m = \frac{VWY}{10}$

Where

C_a = field capacity, area basis, (ha / hr)

C_m = field capacity, material basis, (mg/hr)

W = machine working width, (m)

Y = crop yield, (mg/ ha)

η = field efficiency, (decimal).

The term theoretical field capacity is used to describe the field capacity when the field efficiency is equal to 1.0 Theoretical capacity is achieved when the machine is using 100% of it's width without interruption for turn and other idle time.

For cultivators and other machines that work in rows, the machine working width is equal to the row spacing times the number of rows processed in each pass.

An operator with perfect steering skills would be required to use the full width of machine that does not work in rows. Since operator is not perfect, less than the full width is used in order to ensure coverage of entire land area i.e there is some overlapping of coverage.

2-5-2 Field efficiency:

The theoretical time required to perform a given field operation varies inversely with the theoretical field capacity, and the actual time required to perform the operation will be increased due to overlap, time required for turning at the end of the field, time required for loading or unloading material, etc, such time loses lower field efficiency.

Field efficiency is the ratio between the productivity of machine under field conditions and the theoretical maximum productivity. Field efficiency accounts for failure to utilize the theoretical operating width of the machine, time lost because of operator capability and habits and operating policy, slippage and field characteristics. Travel to and from a field, major repair and maintenance and daily service activity are not included in field time or field efficiency.

Field efficiency is not a constant for a particular machine, but varies with the size and shape of the field, pattern of field operation, crop yield moisture, and crop conditions.

The following activities account as the major factors of time loss in the field:

- Turning and idle travel.
- Material handling (seed, fertilizer, water, chemicals).
- Cleaning clogged equipment.
- Machine adjustment.
- Lubrication and refueling (besides daily service).
- Waiting for other machine.

The following equation can be used to calculate field efficiency.

$$\eta = \frac{actual\ area\ covered\ (w\quad v\quad t\ )}{theoretical\ area\ covered\ (wvt)}$$

Where:

W^- = actual width measured (m)

t^- = effective operating time (hr)

v^- =actual speed (km/hr)

w = theoretical width (m)

v = theoretical speed (km/hr)

t = theoretical time required to complete the operation (hr)

[Table (2.5.2)] Field efficiency, field speed , repair and maintenance cost parameters

Machine	Effie Range %	Type Effic %	Speed Range km/h	Type speed km/h	Est1 life h	Total life R &M Cost %of list price	RF1	RF2
Tillage and Planning								
• Moldboardplow	70-90	85	50-100	70	2000	100	029	18
• Heavy duty disc	70-90	85	55-100	70	2000	60	018	17
• Tandem disc barrow	70-90	80	65-110	100	2000	60	018	17
• Chisel plow	70-90	85	65-105	80	2000	75	028	14
• Field cultivator	70-90	85	80-130	110	2000	70	027	14
• Spring tooth barrow	70-90	85	80-130	110	2000	70	027	14
• Roller packer	70-90	85	70-120	100	2000	40	016	13
• Melcher packer	70-90	80	65-110	80	2000	40	016	13
• Rotary hoe	70-85	80	13-225	190	2000	60	023	14
• Row crop cultivator	70-90	80	50-110	80	2000	80	017	22
• Rotary tiller	70-90	85	20-70	50	1500	80	036	20
• Row crop planter	50-75	65	65-110	90	1500	75	032	231
• Gramdrill	55-80	70	65-110	80	1500	75	032	21
Harvesting:								
• Corn picker sheller	60-75	65	3.0-6.5	4.0	2000	70	0.14	2.3
• Combine	60-75	65	3.0-6.5	5.0	2000	60	0.12	2.3
• Combine (SP)[101]	65-80	70	3.0-6.5	5.0	3000	40	0.14	2.1
• Mower	75-85	80	5.0-10.0	8.0	2000	150	0.46	1.7
• Mower (rotary)	75-90	80	8.0-19.0	11.0	2000	175	0.44	2.0

• Mower conditioner	75-85	80	5.0-10.0	8.0	2500	80	0.18	1.6
• Mower condition (rotary)	75-90	80	8.0-19.0	11.0	2500	100	0.16	2.0
• Wmdrower (SP)	70-85	80	5.0-13.0	8.0	3000	55	0.06	2.0
• Side delivery rake	70-90	80	6.5-13.0	10.0	2500	60	017	1.4
• Rectangular baler	60-85	75	4.0-10.0	6.5	2000	80	0.23	1.8
• Large rectangular baler	70-90	80	6.5-13.0	8.0	3000	75	0.10	1.8
• Large round baler	55-75	65	5.0-13.0	8.0	1500	90	0.43	1.8
• Forge harvester	60-85	70	2.5-8.0	5.0	2500	65	0.15	1.6
• Forage harvester (SP)	60-85	70	2.5-10.0	5.5	4000	50	0.03	2.0
• Sugar beet harvester	50-70	60	6.5-10.0	8.0	1500	100	059	1.3
• Potato harvester	55-70	60	2.5-6.5	4.0	2500	70	0.19	1.4
• Cotton picker (SP)	60-75	70	3.0-6.0	4.5	3000	80	0.11	1.8
Miscellaneous								
• Fertilizer spreader	60-80	70	8.0-16.0	11.0	1200	80	0.63	1.3
• Boom-type sprayer	50-80	65	5.0-11.5	10.5	1500	70	0.41	1.3
• Att0carrier sprayer	55-70	60	3.0-8.0	5.0	2000	60	0.20	1.6
• Bean puller-windrower	70-90	80	6.5-11.5	8.0	2000	60	0.20	1.6
• Footage blower	70-90	80	6.5-11.5	8.0	1200	35	0.28	1.4
• Footage wagon					1500	45	0.22	1.8
• Wagon					2000	50	0.16	1.6
					3000	80	0.19	1.3

2-6 Slip

2-6-1 Definition

Slippage of drive wheel on soil surfaces is a power loss, this loss is measured as

$$S = (D_u - D_L) \times 100 / D_u$$

Where:

S = the slip, percent.

D_u = the advance under no load conditions per wheel or track revolution (m), (ft)

D_L = the advance under actual load condition per wheel or track revolution m/ft

2-6-2 The Negative effect of the slip:

- Increases the fuel consumption.
- More energy is required to complete agricultural operation.
- Reduces field efficiency.
- Reduces operating speed.

2-6-3 Factors affecting the slip:

- The shape and tire size.
- Soil properties and soil texture.
- The type of tractor and implement used.
- Gear selection.
- The weight of the tractor.
- Turning radius with break and without break.

2-6-4 Means to reduce the slip:

- Weighting balance method (ballasting).
- Liquid balance
- Iron balance.
- Decreasing moisture of the soil.
- Shape and number of the lugs, If the number of the lugs increases the slip will decreases.
- If the tire is smooth the slip increases.
- If the thickness of the tire increases the slip will decreases.

2-6-5 Field determination of slip for different soils Implements & tractors:

Measuring wheel slip is simple and only takes a few minutes.

- A typical, un-worked flat area must be chosen in a field that represents normal working conditions.
- One side of a drive tire should be marked by using any marker (clearly seen).
- The distance of the tractor should be measured by certain number of revolutions, at least ten revolutions.
- This step must be repeated on the same experiment land and with similar number of the revolutions.
- After the tractor has been loaded, the distance could be ready for measuring.

Chapter (III)

Material and Methods

Field tests:

Experiments were performed in the farm of the Agricultural engineering department in Soba-south of Khartoum.

3-1 Description of the field experiments & conditions:

Field No (1):

Site: Soba – south of Khartoum.

- Vegetation: No vegetation.
- Past history for cultivation: not tilled.
- Past history for irrigation: dry.
- Type of soil: sandy loam.

Field No (2)

Site: Soba – south of Khartoum.

- Vegetation: sorghum.
- Past history for cultivation: tilled.
- Type of soil: clay soil.

Duration of experiments:

- For slip measurement from 9 am – 12 pm on Feb 2009.
- For draft measurement from 2 pm twice on march 2009.
- For field efficiency measurement" 3 pm – 6 pm twice on April 2009.

3-2 Climatic Condition:

- Rain fall: No

- Temperature : 30 C^o

3-3 Tractors, Implements and Material used:

- Two tractors were used Massy Ferguson (82 hp) was instrumented to measure the drawbar force, and New Holland tractor for measuring the field efficiency and the two tractor for the comparison between the slip values. The details of the tractors specification and tire's are shown in the following Table (3.3).

[Table (3.3)] Specification of tractors used

Weight and dimension	MF 290	New Holland (82hp)
• Static weight	2552 kg	2230 kg
• Overall length	3.89 m	2.2 mm
• Wheel base.	2.29 m	2.5 mm
Ground clearance under		
• Drawbar	381 mm	500 mm
• Front axle	486 mm	490mm
• Rear axel	648 mm	650mm
Tire size		
• Front tire.	14 x 24	7.5-16.8 PR
• Rear tire.	18 x 34	16.9-28.1 PR

Three types of implements used (Dis plow, ridger and rotary hoe)

3.3.1 Disc plow:

The common disc plow consists of disc blades mounted individually on a frame, the disc blades are set at an angle.

Standard disc plows usually have three to six blades spaced to cut 18 to 30 cm/ disc and the disc angles vary from 42^o to 45^o.

The disc diameters are commonly between 60 and 70 cm.

Disc plows are used for primary tillage and they are most suitable for conditions under which moldboard plows do not work satisfactory, such as in hard, dry soils, and assist in covering plant residues, inverting the soil and prevent soil buildup- in sticky soil.

Specification of disc plow used in the experiment:

Attachment	: mounted.
Power requirement	: 70- 80 hp.
Hitching	: 3 point linkage category.
Main frame	: Robust, strong enough to withstand working in heavy clay soil.
Disc type	: plain heavy duty.
Disc diameter	: 665 mm.
Disc thickness	: 6 mm
Number of discs	: 3

Figure (3.3.1) shows the plow used in the experiment and figure (3.3.2) explain the hitching of disc plow.

3.3.2 Ridger:

- Attachment : mounted.

- Power requirement : 70-80 hp
- Ridger body : with wings and shear point suitable to be used in dry ridging.
- Ridger bodies clearance: 510 mm from the ground.

Figure (3.3.3) shows the rigder used in the experiment and figure (3.3.4) shows the hitching of ridger.

Figure (3.3.5) shows the hitching of rotary hoe.

3.3.3 Rotary hoe:

Attachment	: mounted.
Power requirement	: 35-70 hp.
Rotary length	: 450 mm.
Rotary height	: 1200 mm
Rotary weight	: 300 kg.

The specification of drawbar digital dynamometer

- The digital dynamometer is designed to read the force in kg. f from (1.0 -3000 kg.f)
- 5 digit, 1.2 inch (world height 40 mm) digital display with high brightness.
- Anti-shaking and anti-vibrating swing intellectual digital filter stabilizes reading with a stabilization time of less than 5 sec.
- Working environment temperature 5C^{o} – 35C^{o} 85 % R.H.

Figure (3.3.6) shows the drawbar digital dynamometer and figure (3.3.7) shows the tractor with implement and dynamometer.

Material used:

- Stop watch.
- 30 meter steel tape.
- Ruler for measuring depth.
- Digging tools.

- Plastic bags.
- Cylinders for taking soil sample.

Methods use:

Method of draft determination:

- Two tractors were used in these tests with the dynamometer connected between them, as the implements tests were all mounted implements.
- Selection of depths and speeds:
- For each implement 3 depths are used for the test:
  - D_1: 15cm
  - D_2: 20 cm } disc plough
  - D_3: 25 cm
  - D_1: 15cm
  - D_2: 20 cm } ridger
  - D_3: 28 cm

And only one depth = 5 cm was used for the rotary.

For each implement three different speed are used for the test.

  - S_1: 4.1 km/hr
  - S_2: 5.76 km/hr disc plow
  - S_3: 8.28 km/hr

  - S_1: 6.1 km/hr
  - S_2: 3.9 km/hr ridger
  - S_3: 2 km/hr

  - S_1: 4 km/hr

- S_2: 6 km/hr rotary
- S_3: 8 km/hr

- A 60 m distance was taken as a reference for all implements and about 4 readings were taken for each depth and speed and the average value was taken.

Method of field efficiency and field capacity determination:

The objective of this experiment was to compare three different tillage implements (disc plow – ridger – rotaryhoe) in terms of effective field capacity and field efficiency.

Experimental work was done on untilled area of about 100m^2 using 82 hp tractor (Massy 290), experiments were replicated three times in a random manner for all implements.

Field efficiency and effective field capacity were calculate using equation (2-5-2).

3-4 Soil tests:

The analysis of soil was performed in building and road research institute soil lab to determine soil properties and we got the following results.

3-4-1 Grain size Analysis:

Gravel = 2%

Sand = 56%

Clay = 12%

Slit = 30%

By using USDA soil texture triangle, the type of soil is sandy loam.

3-4-2 liquid and plastic limit test:

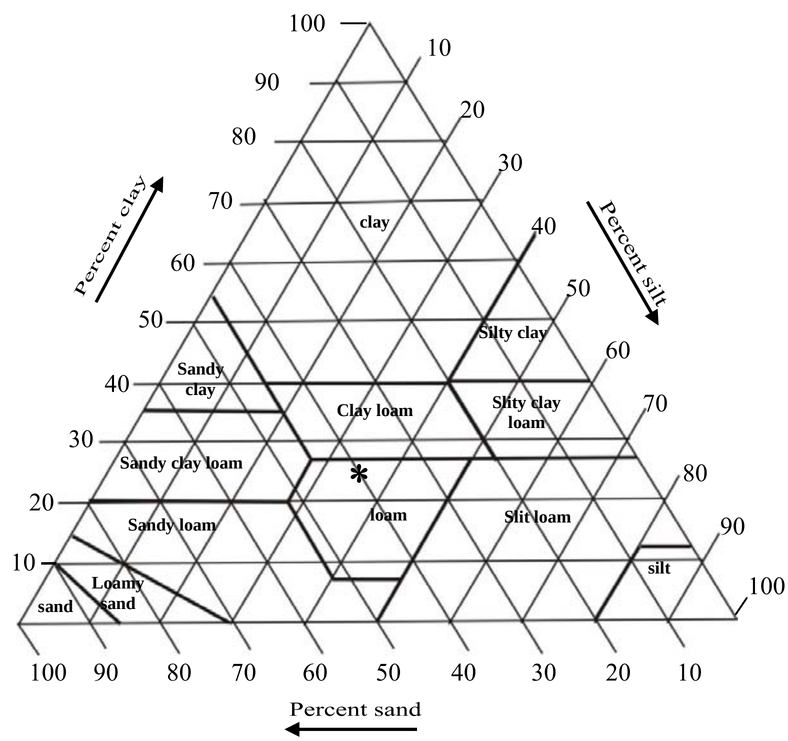
Liquid limit = 34%

Plastic limit = 20%

Plasticity index = 14%

3-4-3 Sieve Analysis test:

B.S Sieve Size (mm)	Retained By Weight (gm)
5.60	0.4
4.76	0.4
2.80	0.5
2.00	0.9
1.40	1.8
1.00	4.0
0.710	7.3
0.500	10.8
0.425	12.0
0.250	16.6
0.212	17.9
0.180	20.1
0.150	21.8
0.125	23.0
0.090	25.7
0.075	26.9
Pan (0.063)	**28.6**



USDA soil Texture triangle for soil classification

4 Results:

4-1 Ridger

Depth 15 cm

	Draft (N) at speed = 6.1 km/hr	**Draft (N) at speed 3.9 km/hr**	**Draft (N) At speed 2 km/hr**
	3240	4470	1420
	4580	5040	4700
	5020	5130	4260
	5510	4420	3720
	5570	6260	4570
Average draft	**Draft** = 4784 N	**Draft** = 5064 N	**Draft** = 4334 N
Average P_{db}	8106.2 W	5486 W	2407.7 W

Actual drawbar power:

$$P_{db} = \frac{D*S}{3.6}$$

D = 4784 N , S = 6.1 km/hr

$$P_{db} = \frac{4784*6.1}{3.6} = 8106.2 \text{ w}$$

D = 5064 N , S = 3.9 km / hr

$$P_{db} = \frac{5064*3.9}{3.6} = 5486 \text{ w}$$

D = 4334 N , S = 2 km / hr

$$P_{db} = \frac{4334*2}{3.6} = 2407.7 \text{ w}$$

Depth 20 Cm

	Draft (N) at speed = 2 km/hr	Draft (N) at speed 3.9 km/hr	Draft (N) At speed 6.1 km/hr
	-	4570	4560
	5040	5320	5210
	4700	4170	4710
	3860	5570	6200
	4180	-	-
Average draft	Draft = 4445 N	Draft = 4907.5 N	Draft = 5170 N
Average P_{db}	2469.4 W	5316.4 W	8760 W

Actual Drawbar power

$$P_{db} = \frac{D*S}{3.6}$$

D = 5170 N , S = 6.1 km / hr

$$P_{db} = \frac{5170*6.1}{3.6} = 8760 \text{ w}$$

D = 4907.5 N S = 3.9 km/hr

$$P_{db} =, \frac{4907.5*3.9}{3.6} = 5316.4 \text{ w}$$

D = 4445N , S = 2km / hr

$$P_{db} = \frac{4445*3.6}{3.6} = 2469.4 \text{ w}$$

Depth 28 Cm

	Draft (N) at speed = 6.1 km/hr	Draft (N) at speed 3.9 km/hr	Draft (N) At speed 3.6 km/hr
	4370	4260	3520
	3260	3990	4470
	-	4470	3510
	-	5320	4170
	2320	4520	5550
Average draft	Draft = 5332 N	Draft = 5142 N	Draft = 4925 N
Average P_{db}	9035 w	5571 w	2736 w

Actual Drawbar power

$P_{db} = \frac{D*S}{3.6}$

D = 5332 N , S = 6.1 km / hr

$P_{db} = \frac{5332*6.1}{3.6}$ = 9035 w

D = 5142 N S = 3.9 km/hr

$P_{db} = \frac{5142*3.9}{3.6}$ = 5571 w

D = 4925 N , S = 2 km / hr

$P_{db} = \frac{4925*2}{3.6}$ = 2736 w

4-2 Disc Plow:

Depth = 15 cm

	Draft (N) at speed = 4.1 km/hr	Draft (N) at speed 5.7 km/hr	Draft (N) At speed 8.28 km/hr
	- 3650 4160 4250 4110	4060 3140 5420 3560 -	4250 3630 5000 5100 -
Average draft	Draft = 4042 N	Draft = 4054 N	Draft = 4495 N
Average P_{db}	4603 w	6404w	10238.6

Actual Drawbar power

$P_{db} = \frac{D*S}{3.6}$

D = 4042 N S = 4.1 km / hr

P_{db} = 4603 w

D = 4045 N S = 5.7 km/hr

P_{db} = 6404 w

D = 4495N , S = 8.28 km / hr

P_{db} = 10238.6 w

Depth 20 Cm

	Draft (N) at speed = 4.1 km/hr	Draft (N) at speed 5.76 km/hr	Draft (N) At speed 8.28 km/hr
	4560 5060 -	6130 5420 6230	4260 5500 5800
Average draft	Draft = 4810 N	Draft = 5926N	Draft = 5180N
Average P_{db}	5478w	9481.6 w	11913.8 w

Actual Drawbar power

$P_{db} = \frac{D*S}{3.6}$

D = 4810N , S = 4.1 km / hr

P_{db} = 5478 w

D = 5926 N , S = 5.76 km/hr

P_{db} = 9481.6 w

D = 5180 N , S = 8.28 km / hr

P_{db} = 11913.8 w

Depth 25 Cm

	Draft (N) at speed = 4.1 km/hr	Draft (N) at speed 5.76 km/hr	Draft (N) At speed 8.28 km/hr
	5000 4500 5500	5600 6000 5200	5850 5760 5790
Average draft	Draft = 5000N	Draft = 5600 N	Draft = 5800 N
Average P_{db}	5694.4w	8960.6 w	13340 w

Actual Drawbar power

$$P_{db} = \frac{D*S}{3.6}$$

D = 5000 N S = 4.1 km / hr

P_{db} = 5694.4 w

D = 5600 N S = 5.76 km/hr

P_{db} = 8960 .6 w

D = 5800 N S = 8.28 km / hr

P_{db} = 13340 w

4-3 Rotary hoe

Depth 5 Cm

	Draft (N) at speed = 4 km/hr	**Draft (N) at speed 6 km/hr**	**Draft (N) At speed 8 km/hr**
	4002	5008	4403
	4708	5307	5207
	5105	5505	5706
	6102	5607	5409
Average draft	Draft = 4979.2 N	Draft = 5356.75 N	Draft = 5181 N
Average P_{db}	5532 w	8927.9 w	11513.8 w

Actual Drawbar power

$$P_{db} = \frac{D*S}{3.6}$$

D = 4979.2 N S = 4 km / hr

P_{db} = 5532 w

D = 5356.75N S = 6 km/hr

P_{db} = 8927.9 w

D = 5181 N S = 8 km / hr

P_{db} = 11513.8 w

4-4 Result of Field efficiency for rotary hoe:

No of Experiment	1	2	3	average
Implement working width (m)	1.5	1.5	1.5	1.5
Theoretical width (m)	1.57	1.57	1.57	1.57
Actual time (s)	05:18	05:48	06:30	05:65
Theoretical time (s)	13:12	08:30	09:00	10:14
Theoretical speed (km/hr)	7	7	7	7
Actual speed (km/hr)	6.62	6.62	6.62	6.62

4-5 Result of Field efficiency for disc plow:

No of Experiment	1	2	3	average
Implement working width (m)	1.1	1.1	1.1	1.1
Theoretical width (m)	1.8	1.8	1.8	1.8
Actual time (s)	05:00	05:00	06:00	5:53
Theoretical time (s)	13:30	13:00	12:00	12:7
Theoretical speed (km/hr)	7	7	7	7
Actual speed (km/hr)	6.62	6.62	6.62	6.62

4-6 Result of Field efficiency for ridger:

No of Experiment	1	2	3	average
Implement working width (m)	1.2	1.2	1.2	1.2
Theoretical width (m)	2.4	2.4	2.4	2.4
Actual time (s)	02:30	02:30	02:00	2:33
Theoretical time (s)	06:30	06:00	05:00	5:30
Theoretical speed (km/hr)	7	7	7	7

Actual speed (km/hr)	6.62	6.62	6.62	6.62

Results &calculation

4-7 Ridger:

(A) Depth = 15 cm

Implement draft:

D_i = F_i {A + B (S) + C (S^2)} wd

A = 185 , B = 9.5 , C = 0 , F_2 = 0.88

W = 1.2 m ,D = 15 cm , S = 6.1 km / hr

D_I = 0.88 { 185 + 9.5 (6.1)} * 1.2 * 15 = 3848.32 N

W = 1.2 m D = 15 cm S = 3.9 km/ hr

D_I = 0.88 {185 + 9.5 (3.9)] * 1.2 * 15 = 3517.2 N

W = 1.2 m D = 15 cm S = 2 km/hr

D_I = 0.88 {185 + 9.5 (2)] * 1.2 * 15 = 3077.5 N

Drawbar Power

$P_{db} = \frac{D_I * S}{3.6}$

S = 6.1 km/ hr , D_I = 3418 N

$P_{db} = \frac{3848.32*6.1}{3.6}$ = 6520 w

S = 3.9 km/ hr D_I = 3130 N

$P_{db} = \frac{3517.2*3.9}{3.6}$ = 3810 w

S = 3.6 km/hr D_I = 3077.5 N

$P_{db} = \frac{3472.12*2}{3.6}$ D_1 = 1795.2 w

(B) Depth = 20 cm

Implement draft:

D_I = F_i {A + B (S) + C (S^2)} wd

A = 185 , B = 9.5 , C = 0 , F_2 = 0.88

W = 1.2 m ,D = 20 cm , S = 6.1 km / hr

D_I = 0.88 { 185 + 9.5 (6.1)} * 1.2 * 20 = 5131.1 N

W = 1.2 m D = 20 cm S = 3.9 km/ hr

D_I = 0.88 {185 + 9.5 (3.9)] * 1.2 * 20 = 3944.25 N

W = 1.2 m D = 20 cm S = 2 km/hr

D_I = 0.88 {185 + 9.5 (2)] * 1.2 * 20 = 3926.2 N

Drawbar Power

$P_{db} = \frac{D_I * S}{3.6}$

S = 6.1 km/ hr , D_I = 5131.1 N

$P_{db} = \frac{5131.1 * 6.1}{3.6}$ = 8694 w

S = 3.9 km/ hr D_I = 3944.25 N

$P_{db} = \frac{3944.25 * 3.9}{3.6}$ = 4272.9 w

S = 2 km/hr D_I = 3926.2 N

$P_{db} = \frac{3926.2 * 2}{3.6}$ = 2181.2 w

(C) Depth = 28 cm

Implement draft:

D_I = F_i {A + B (S) + C (S^2)} wd

A = 185 , B = 9.5 , C = 0 , F_2 = 0.88

W = 1.2 m ,D = 28 cm , S = 6.1 km / hr

D_I = 0.88 { 185 + 9.5 (6.1)} * 1.2 * 28 = 7183.5 N

W = 1.2 m D = 28 cm S = 3.9 km/ hr

D_I = 0.88 {185 + 9.5 (3.9)] * 1.2 * 28 = 6565.5 N

W = 1.2 m D = 28 cm S = 2 km/hr

D_I = 0.88 {185 + 9.5 (2)] * 1.2 * 28 = 5489 N

Drawbar Power

$P_{db} = \frac{D_I * S}{3.6}$

S = 6.1 km/ hr , D_I = 7183.5 N

$P_{db} = \frac{7183.5*6.1}{3.6}$ = 12172.1 w

S = 3.9 km/ hr D_I = 6565.5 N

$P_{db} = \frac{6565.5 *3.9}{3.6}$ = 7112.7 w

S = 2 km/hr D_I = 5489 N

$P_{db} = \frac{5489*2}{3.6}$ = 3049.4 w

Table (4-1) Result of Estimated draft and drawbar power

Depth (cm)	Speed (km/hr)	D_I (N)	P_{db} (w)
15	6.1	3848.32	6520
15	3.9	3517.2	3810
15	2	3231.3	1795.2
20	6.1	5131.1	8694
20	3.9	3944.25	4272.9
20	2	3926.2	2181.2
28	6.1	7182.5	12172.1
28	3.9	6565.5	7112.7
28	2	5489	3049.4

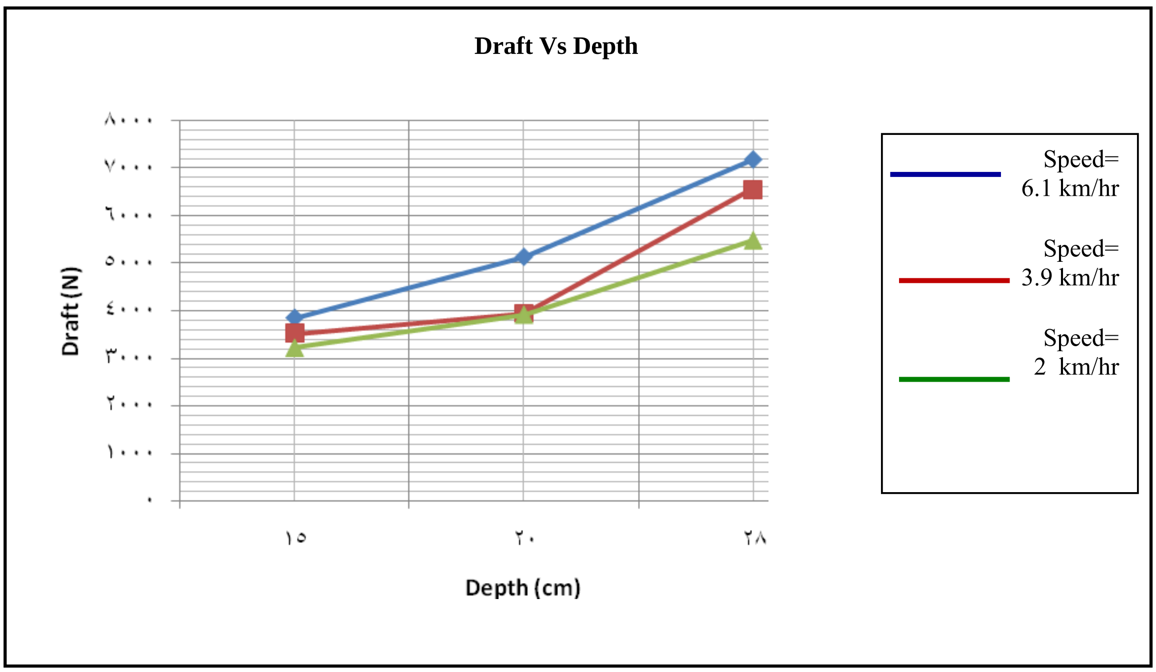


Figure (4-1) Shows draft Vs depth at different speeds (6.1, 3.9, 2) km/hr

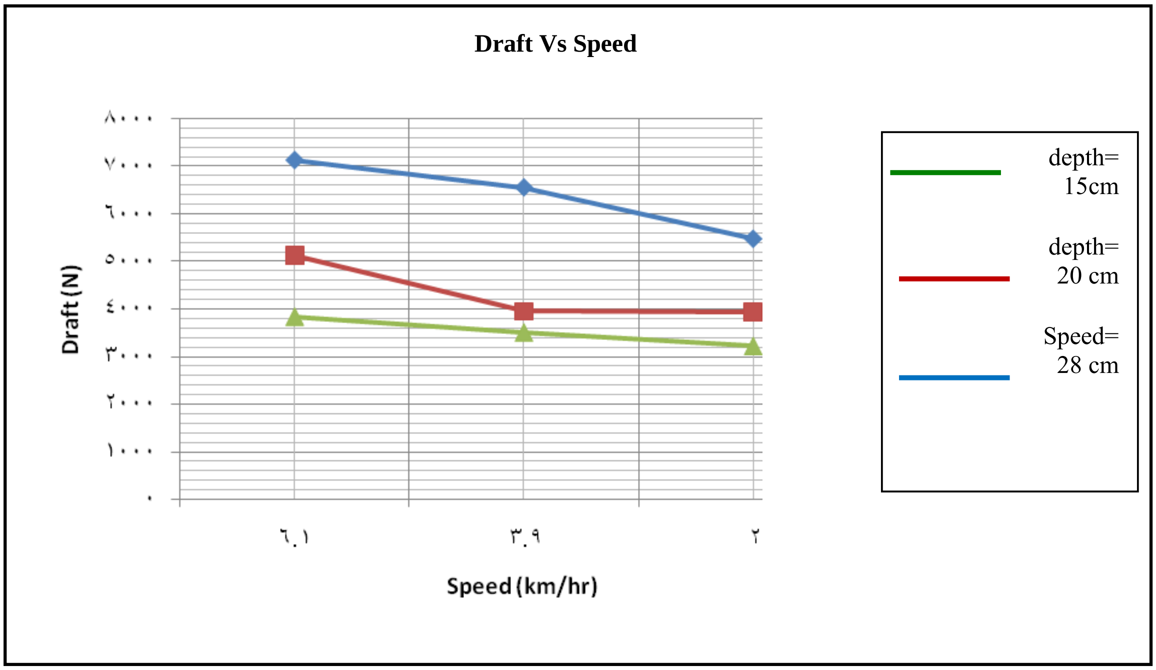


Figure (4-2) shows draft Vs speed at three different depths (15, 20, 28) cm

4-8 Disc Plow

(A) Depth = 15 cm

Implement draft:

D_i $= F_i \{A + B (S) + C (S^2)\}$ wd

A = 390 , B = 19 , C = 0 , $F_2 = 0.88$

W = 1.1 m , D =15 cm , S = 4.1 km / hr

D_I = 0.88 {390 + 19 (4.1)} * 1.1 * 15 = 6793.9 N

W = 1.1 m D = 15 cm S = 5.7 km/ hr

D_I = 0.88 {390 + 19 (5.7)] * 1.1 * 15 = 7235.3 N

W = 1.1 m D = 15 cm S = 8.28 km/hr

D_I = 0.88 {390 + 19 (8.2)] * 1.1 * 15 = 7925 N

Drawbar Power

$P_{db} = \frac{D_I * S}{3.6}$

$S = 4.1$ km/ hr , $D_I = 6793.9$ N

$P_{db} = \frac{6793.9 * 4.1}{3.6} = 7739.5$ w

$S = 5.7$ km/ hr $D_I = 7235.3$ N

$P_{db} = \frac{7235.3 * 5.7}{3.6} = 11455.9$ w

$S = 8.2$ km/hr $D_I = 7925$ N

$P_{db} = \frac{7925 * 8.2}{3.6} = 18051.4$ w

(B) Depth = 20 cm

Implement draft:

D_i = F_i {A + B (S) + C (S^2)} wd

A = 390 , B = 19 , C = 0 , F_2 = 0.88

W = 1.1 m , D = 20 cm , S = 4.1 km / hr

D_I = 0.88 {390 + 19 (4.1)} * 1.1 * 20 = 9058 N

W = 1.1 m D = 20 cm S = 5.7 km/ hr

D_I = 0.88 {390 + 19 (5.7)] * 1.1 * 20 = 9647 N

W = 1.1 m D = 20 cm S = 8.2 km/hr

D_I = 0.88 {390 + 19 (8.2)] * 1.1 * 20 = 10566 N

Drawbar Power

$P_{db} = \frac{D_I * S}{3.6}$

S = 4.1 km/ hr , D_I = 9058 N

$P_{db} = \frac{9058 * 4.1}{3.6}$ = 10316 w

S = 5.7 km/ hr D_I = 9647 N

$P_{db} = \frac{9647 * 5.7}{3.6}$ = 15274 w

S = 8.2 km/hr D_I = 10566 N

$P_{db} = \frac{10566 * 8.2}{3.6}$ = 24068 w

(C) Depth = 25 cm

Implement draft:

D_i = F_i {A + B (S) + C (S^2)} wd

A = 390 , B = 19 , C = 0 , F_2 = 0.88

W = 1.1 m , D = 28 cm , S = 4.1 km / hr

D_I = 0.88 {390 + 19 (4.1)} * 1.1 * 25 = 11323.18 N

W = 1.1 m D = 25 cm S = 5.7 km/ hr

D_I = 0.88 {390 + 19 (5.7)] * 1.1 * 25 = 12058.8 N

W = 1.1 m D = 25 cm S = 8.2 km/hr

D_I = 0.88 {390 + 19 (8.2)] * 1.1 * 25 = 13208.3 N

Drawbar Power

$P_{db} = \frac{D_I * S}{3.6}$

S = 4.1 km/ hr , D_I = 11323.18 N

$P_{db} = \frac{11323.18 * 4.1}{3.6}$ = 12895 w

S = 5.7 km/ hr D_I = 12058.8 N

$P_{db} = \frac{12058.8 * 5.7}{3.6}$ = 19093 w

S = 8.2 km/hr D_I = 13208 N

$P_{db} = \frac{13208 * 8.2}{3.6}$ = 30085 w

Table (4-2) Result of Estimated draft and drawbar power

Depth (cm)	Speed (km/hr)	D_I (N)	P_{db} (w)
15	4.1	6793.9	7737.5
15	5.7	7235.3	11455.9
15	8.2	7925	18051.4
20	4.1	9058	10316
20	5.7	9647	15274
20	8.2	10566	24068
25	4.1	11323.18	12985
25	5.7	12058.8	19093
25	8.2	13208.3	30085

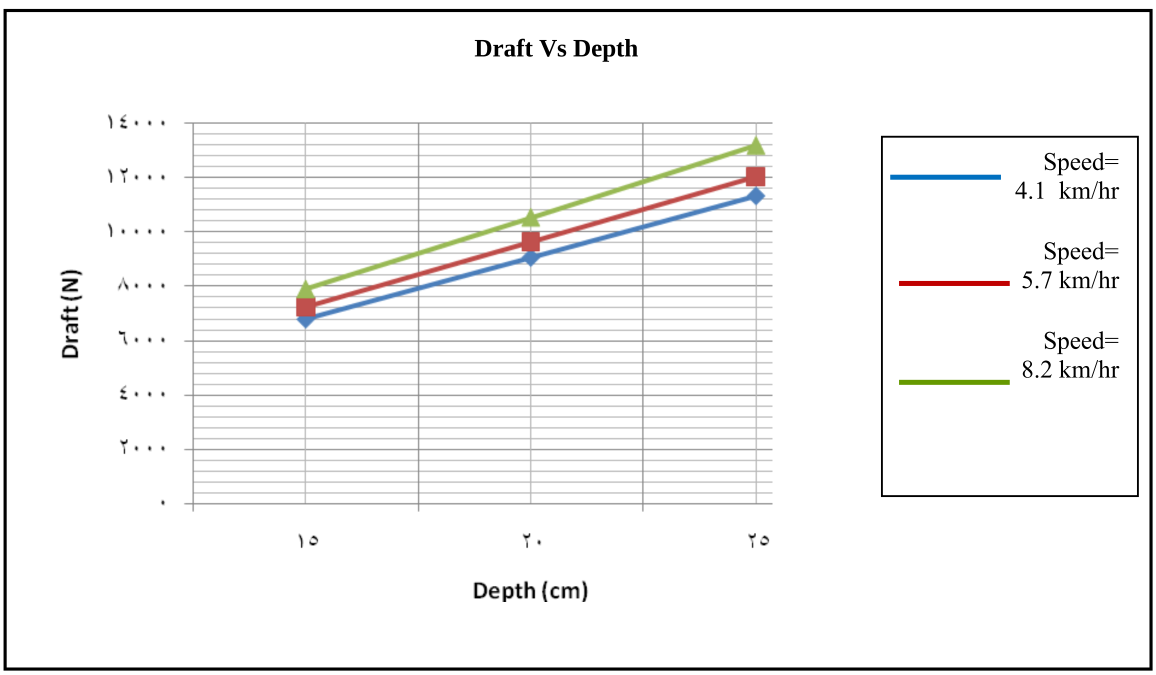


Figure (4-3) shows draft Vs depth at three speeds(4.1, 5.7, 8.2) km/hr

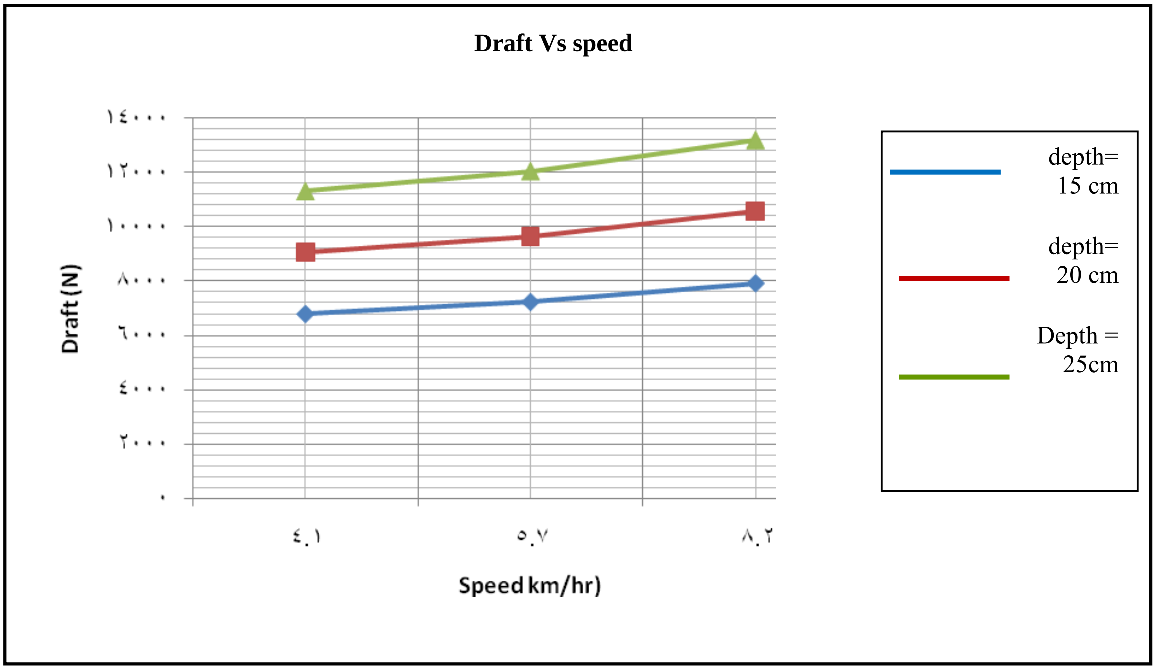


Figure (4-4) shows draft Vs speed at three depths (15, 20, 25) cm

4-9 Rotary Hoe

Depth = 5 cm

Implement draft:

D_i = F_i {A + B (S) + C (S^2)} wd

A = 600 , B = 0 , C = 0 , F_3 = 1

W = 1.50 m , D = 5 cm , S = 4 km / hr

D_I = 1 {600 + 0 +0 } * 1.50 * 5 = 4500 N

W = 1.50 m D = 5 cm S = 6 km/ hr

D_I = 1{600 + 0 +0] * 1.50 * 5 = 4500 N

W = 1.50 m D = 5 cm S = 8 km/hr

D_I = 1{600 + 0 + 0] * 1.50 * 5 = 4500 N

Drawbar Power

P_{db} = $\frac{D_I * S}{3.6}$

S = 4 km/ hr , D_I = 4500 N

P_{db} = $\frac{4500*4}{3.6}$ = 5000 w

S = 6 km/ hr D_I = 4500 N

P_{db} = $\frac{4500 * 6}{3.6}$ = 7500 w

S = 8 km/hr D_I = 4500 N

P_{db} = $\frac{4500* 8}{3.6}$ = 10000 w

Table (4.3) Result of estimated draft and drawbar power

Depth (cm)	Speed (km/hr)	D_I (N)	P_{db} (w)
5	4	4500	5000
5	6	4500	7500
5	8	4500	10000

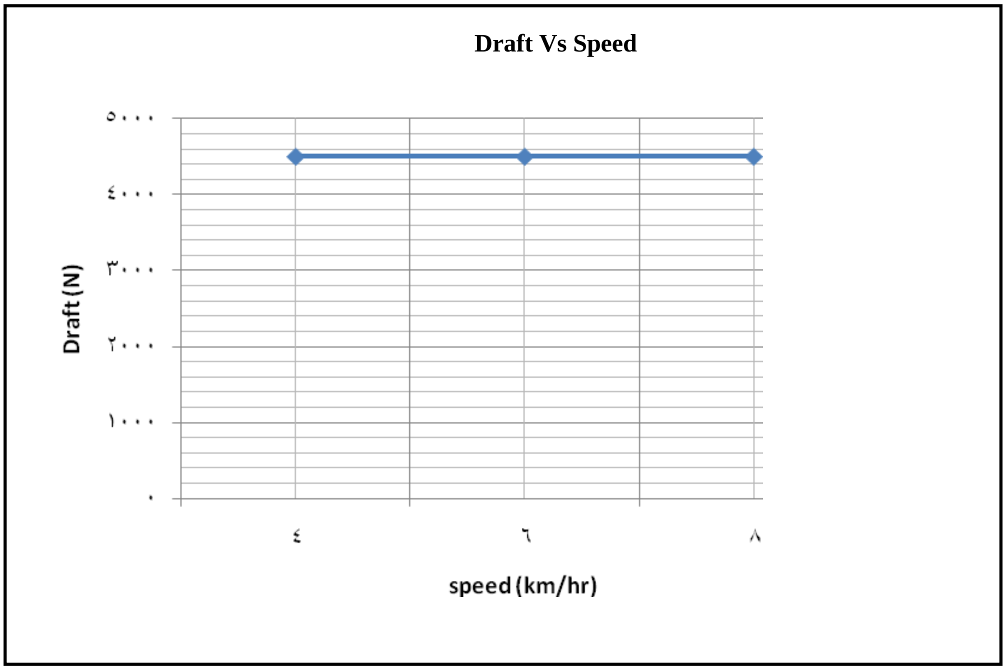


Figure (4-5) shows draft Vs speed at depth (5) cm

4-10 Field Efficiency and field capacity calculation

4-10-1 Rotary hoe

Experiment No (1)

$$\eta = \frac{w^{-} v^{-} t^{-}}{w\ v\ t}$$

w^{-} = 1.50 m , v^{-} = 6.62 km/hr , t^{-} = 05:18 S

w = 1.57 m , v = 7 km/hr , t = 13:12 S

$$\eta = \frac{1.5*6.62*5.18}{1.57*7*13.12}$$ **= 38.6%**

Field capacity $= \frac{v\ w\ \eta}{10}$

$$= \frac{1.57*7*0.386}{10}$$ **= 0.41 ha / hr**

Experiment No (2)

$$\eta = \frac{w^{-} v^{-} t^{-}}{w\ v\ t}$$

w^{-} = 1.50 m , v^{-} = 6.62 km/hr , t^{-} = 05:48 S

w = 1.57 m , v = 7 km/hr , t = 08: 30S

$$\eta = \frac{1.5*6.62*5.8}{1.57*7*8.5}$$ **= 52%**

Field capacity $= \frac{v\ w\ \eta}{10}$

$$= \frac{1.57*7*0.52}{10}$$ **= 0.575 ha / hr**

Experiment No (3)

$$\eta = \frac{w^{-} v^{-} t^{-}}{w \ v \ t}$$

w^{-} = 1.50 m , v^{-} = 6.62 km/hr , t^{-} = 06 : 30 S

w = 1.57 m , v = 7 km/hr , t = 09 : 00 S

$$\eta = \frac{1.5*6.62*6.5}{1.57*7*9}$$ **= 65.3 %**

$$\text{Field capacity} = \frac{v \ w \ \eta}{10}$$

$$= \frac{1.57*7*0.653}{10}$$ **= 0.71 ha / hr**

4-10-2 Disc Plow:

Experiment No (1)

$$\eta = \frac{w^{-} v^{-} t^{-}}{w \ v \ t}$$

w^{-} = 1.10 m , v^{-} = 6.62 km/hr , t^{-} = 05:00 S

w = 1.80 m , v = 7 km/hr , t = 13:30 S

$$\eta = \frac{1.1*6.62*5}{1.8*7*13.5}$$ **= 21%**

$$\text{Field capacity} = \frac{v \ w \ \eta}{10}$$

$$= \frac{7*0.21*1.8}{10}$$ **= 0.26 ha / hr**

Experiment No (2)

$$\eta = \frac{w^{-} v^{-} t^{-}}{w \ v \ t}$$

w^{-} = 1.10 m , v^{-} = 6.62 km/hr , t^{-} = 05:00 S

w = 1.80 m , v = 7 km/hr , t = 13:00 S

$$\eta = \frac{1.1*6.62*5}{1.8*7*13}$$ **= 22%**

$$\text{Field capacity} = \frac{v \ w \ \eta}{10}$$

$$= \frac{7*1.8*0.22}{10}$$ **= 0.27 ha / hr**

Experiment No (3)

$$\eta = \frac{w^- v^- t^-}{w\ v\ t}$$

$w^- = 1.10$ m , $v^- = 6.62$ km/hr , t^- = 06 : 00 S

$w = 1.80$ m , $v = 7$ km/hr , t = 12 : 00 S

$$\eta = \frac{1.1*6.62*6}{1.8*7*12}$$ **= 28%**

Field capacity $= \frac{v\ w\ \eta}{10}$

$$= \frac{1.8*7*0.28}{10}$$ **= 0.35ha / hr**

4-10-3 Ridger:

Experiment No (1)

$$\eta = \frac{w^- v^- t^-}{w\ v\ t}$$

$w^- = 1.20$ m , $v^- = 6.62$ km/hr , t^- = 02:30 S

$w = 2.40$ m , $v = 7$ km/hr , t = 06:30 S

$$\eta = \frac{1.2*6.62*2.5}{2.4*7*6.5}$$ **= 18%**

Field capacity $= \frac{v\ w\ \eta}{10}$

$$= \frac{7*2.4*0.18}{10}$$ **= 0.3 ha / hr**

Experiment No (2)

$$\eta = \frac{w^- v^- t^-}{w\ v\ t}$$

$w^- = 1.20$ m , $v^- = 6.62$ km/hr , t^- = 02:30 S

$w = 2.40$ m , $v = 7$ km/hr , t = 06:00 S

$$\eta = \frac{1.2*6.62*2.5}{2.4*7*6}$$ **= 20%**

Field capacity $= \frac{v\ w\ \eta}{10}$

$$= \frac{7*2.4*0.2}{10}$$ **= 0.33 ha / hr**

Experiment No (3)

$\eta \quad = \frac{w^- v^- t^-}{w\ v\ t}$

w^- = 1.20 m , v^- = 6.62 km/hr , t^- = 02 : 00 S

w = 2.40 m , v = 7 km/hr , t = 05 : 00 S

$\eta \quad = \frac{1.2*6.62*2}{2.4*7*5}$ **= 19%**

Field capacity $= \frac{v\ w\ \eta}{10}$

$= \frac{2.4*7*0.19}{10}$ **= 0.32ha / hr**

4-11 Comparison

4-11-1 Ridger

Width (m)	Depth (cm)	Speed (Km/hr)	Calculated Draft (N)	Measured draft (N)	Calculated P_{db} (w)	Measured P_{db} (w)	Specific drat (N/cm^2	% Range of draft variation
1.20	15	6.1	3848	4784	6520	8106.2	2.65	19.5%
1.20	15	3.9	3517.2	5064	3810	5486	2.8	30%
1.20	15	2	3231	4334	1795	2407.7	2.4	25%
1.20	20	6.1	5131.1	5170	8694	8760	2.1	7.5%
1.20	20	3.9	3944.2	4907	4272.9	5316	2	19%
1.20	20	2	3926.2	4445	2181.2	2469	1.85	11%
1.20	28	6.1	7183.5	5352	12172.1	9055	1.6	25%
1.20	28	3.9	6585.9	5142	7112.7	5571	1.5	21%
1.20	28	2	5489	4925	3049.4	2736	1.46	10%

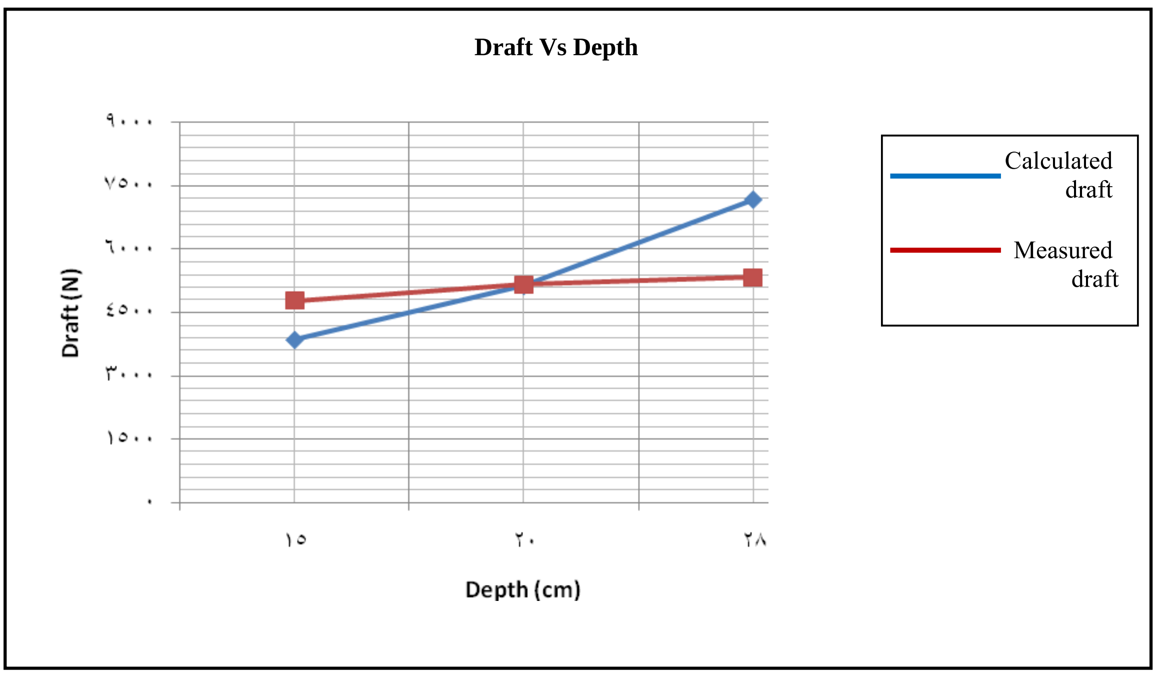


Figure (4-6) Draft Vs Depth at speed (6.1 km/hr)

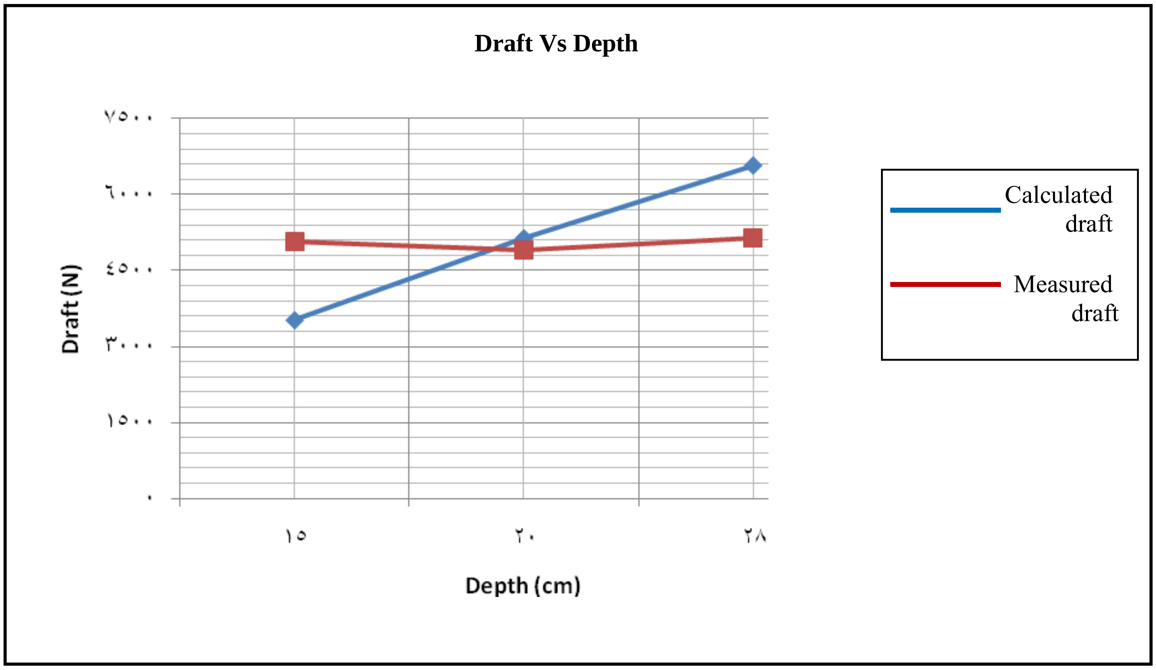


Figure (4 -7) Draft Vs Depth at speed (3.9 km/hr)

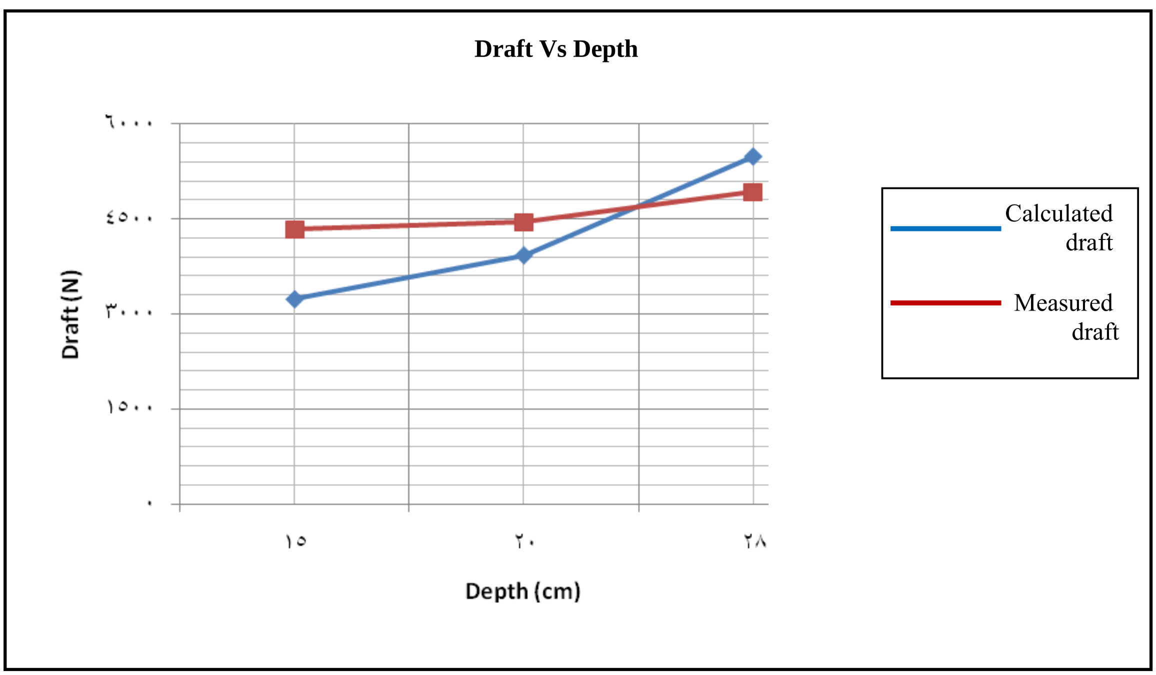


Figure (4-8) Draft Vs Depth at speed (2 km/hr)

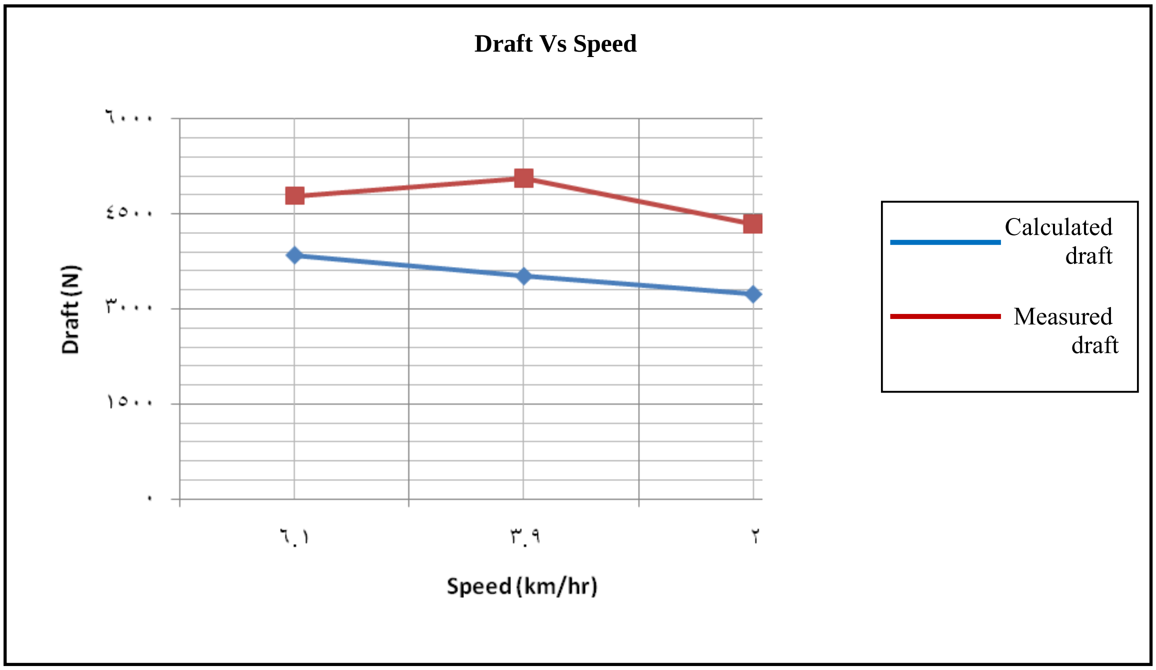


Figure (4-9) Draft Vs speed at depth (15 cm)

Draft Vs Speed

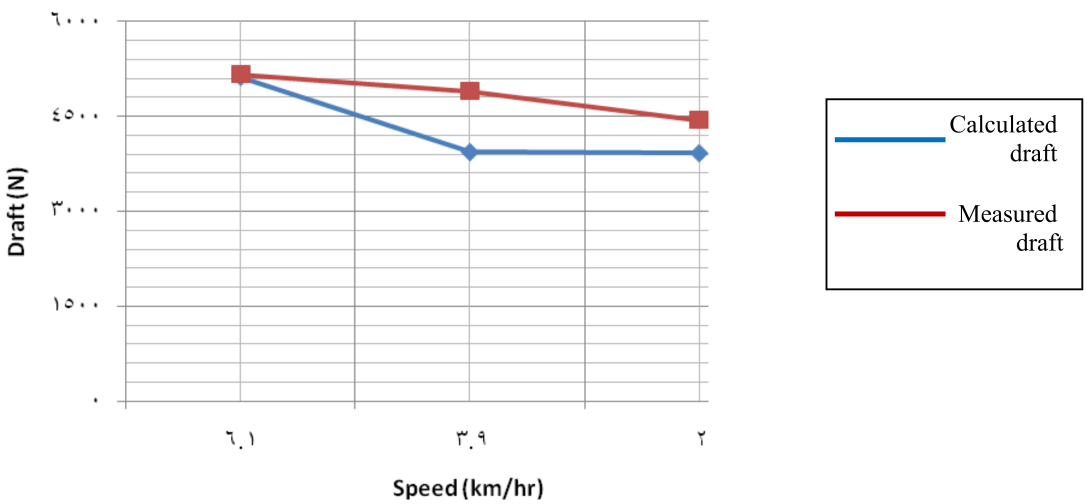


Figure (4-10) Draft Vs speed at depth (20 cm)

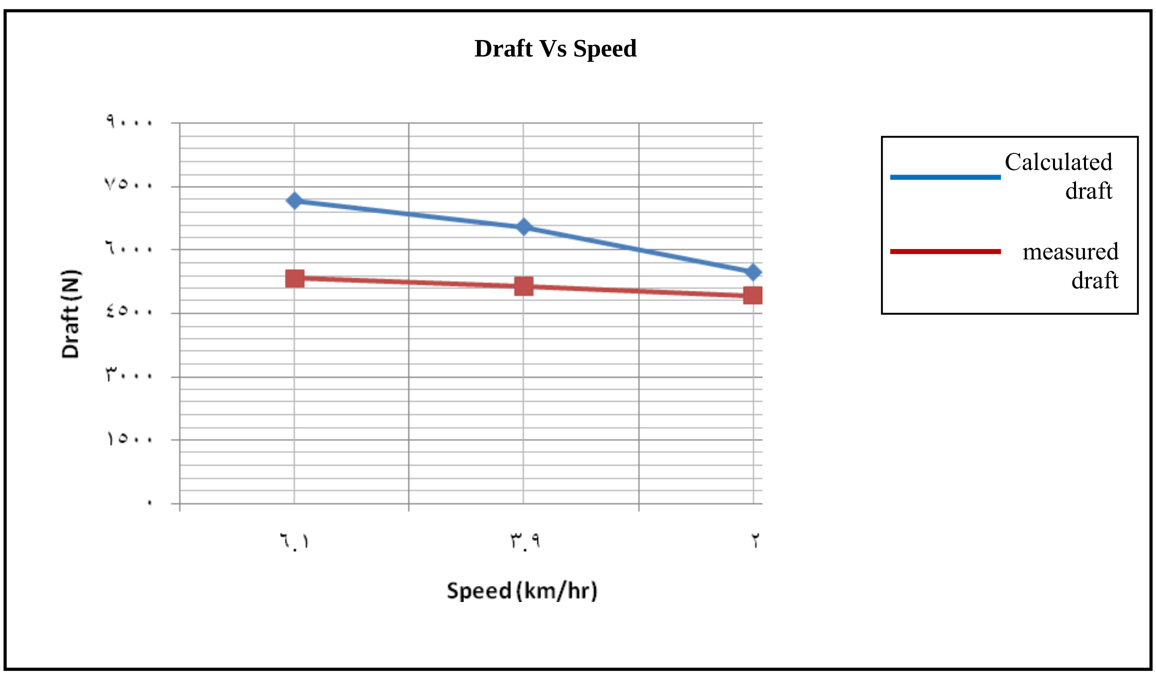


Figure (4-11) Draft Vs speed at depth (28 cm)

4-11-2 Disc Plow

Width (m)	Depth (cm)	Speed (Km/hr)	Calculated Draft (N)	Measured draft (N)	Calculated P_{db} (w)	Measured P_{db} (w)	Specific drat (N/cm^2)	% Range of draft variation
1.10	15	4.1	6793.9	4042	7737.5	4603	2.44	40%
1.10	15	5.7	7235.3	4554	11455.9	4606	2.45	43%
1.10	15	8.2	7925	4405	18051.4	10238.6	2.66	43%
1.10	20	4.1	9058	4810	10316	5478	2.18	45%
1.10	20	5.7	9647	5926	15274	94816	2.69	38%
1.10	20	8.2	10566	5180	24068	11913.8	2.35	50%
1.10	25	4.1	11323	5000	8150.2	12895	1.80	54%
1.10	25	5.7	12058	5600	6625.6	19093	2.04	53%
1.10	25	8.2	13208	5800	18001.5	30085	2.12	55%

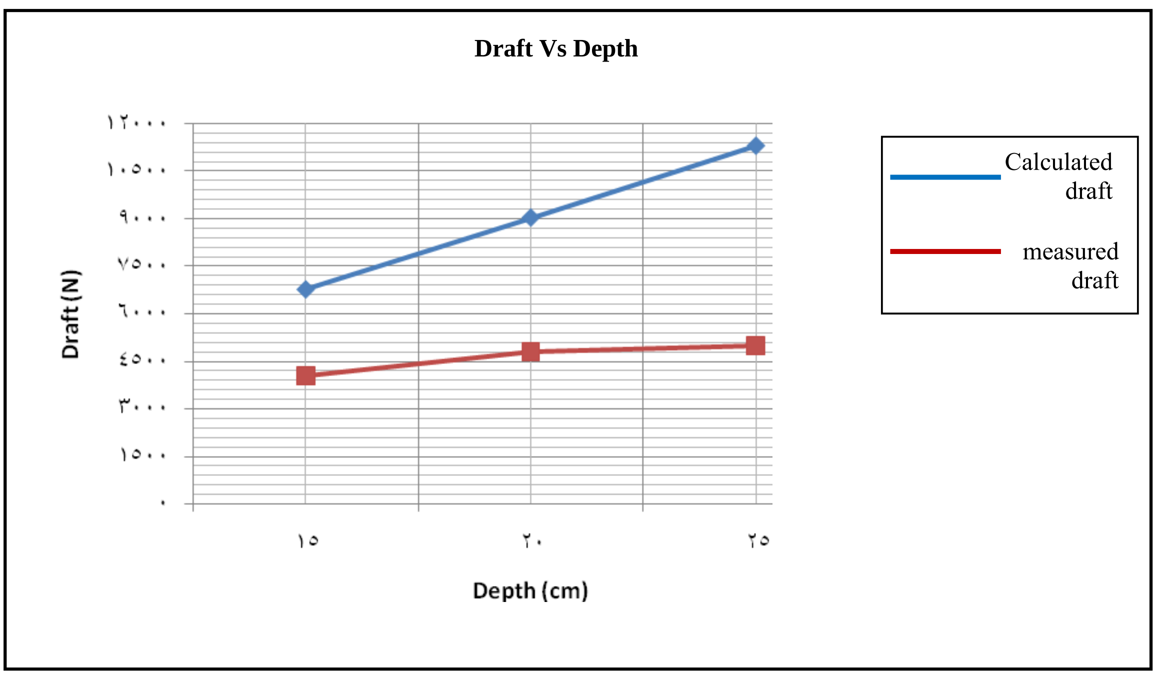


Figure (4-12) Draft Vs depth at speed (4.1 km/hr)

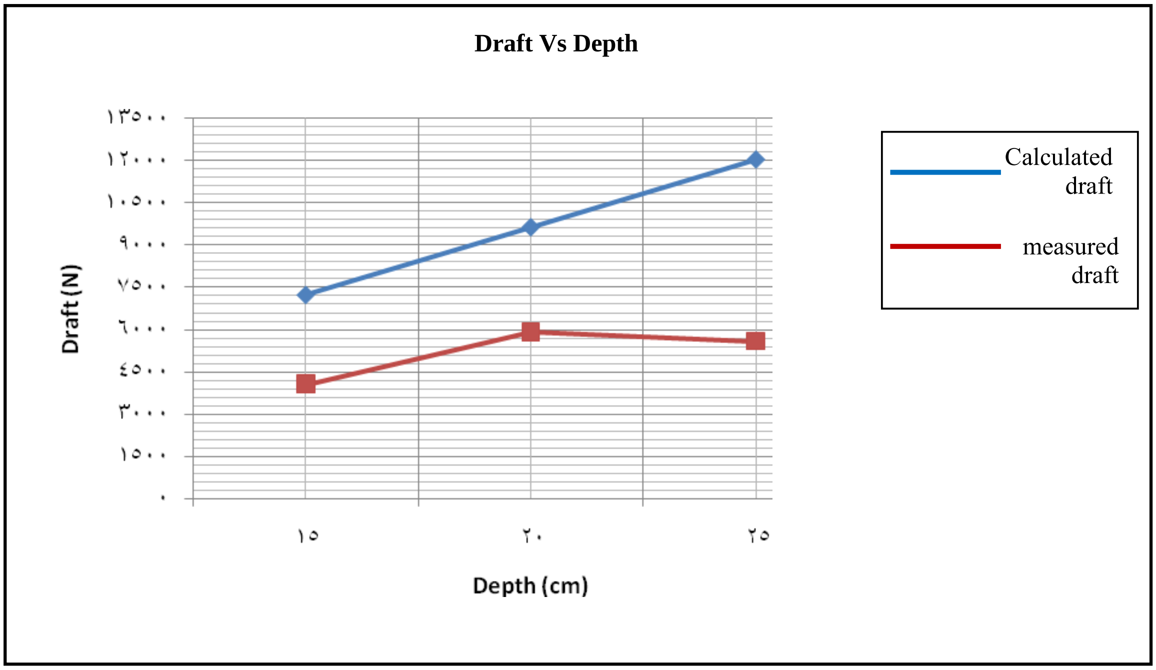


Figure (4-13) Draft Vs depth at speed (5.7 km/hr)

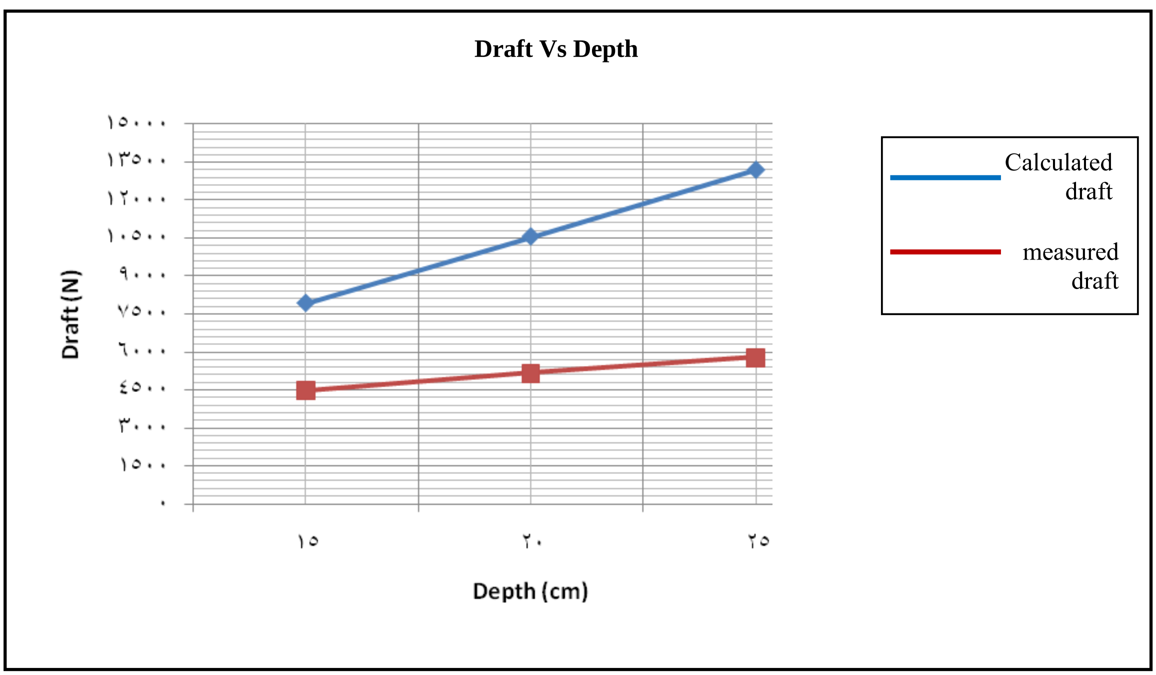


Figure (4-14) Draft Vs depth at speed (8.2 km/hr)

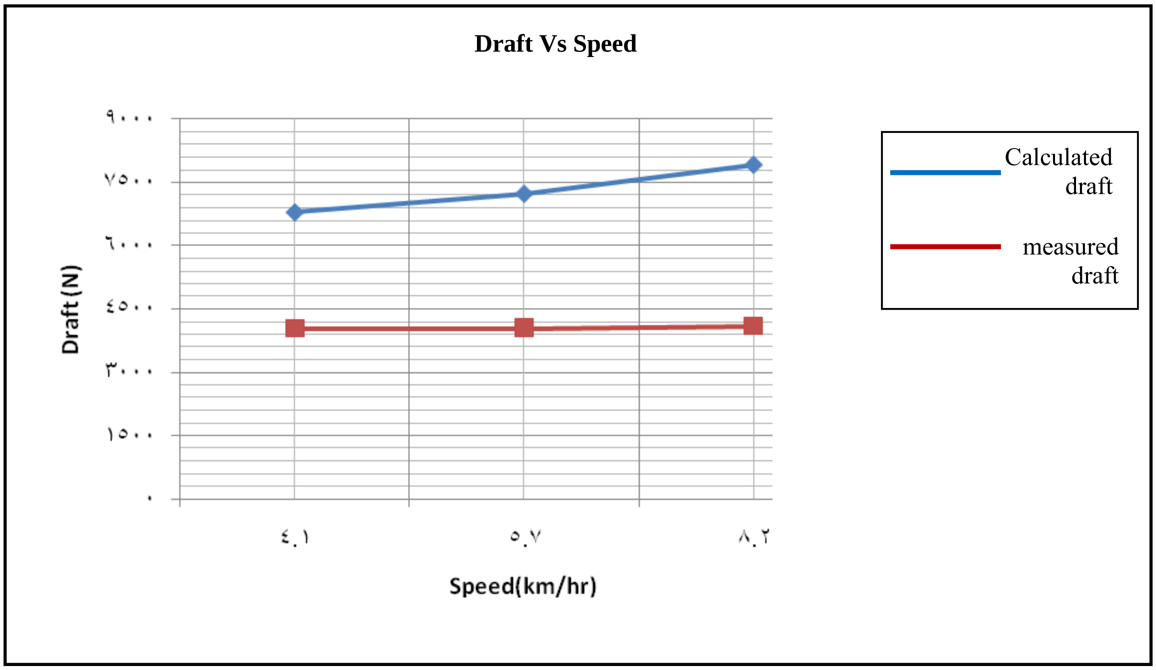
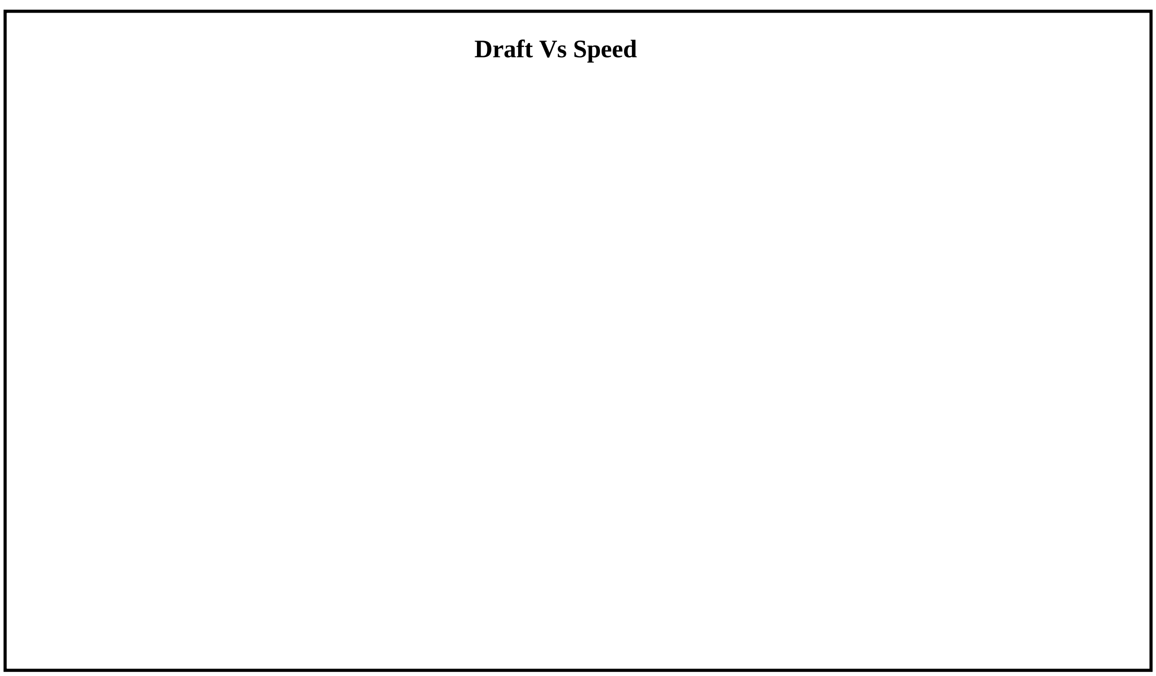


Figure (4-15) Draft Vs speed at depth (15 cm)



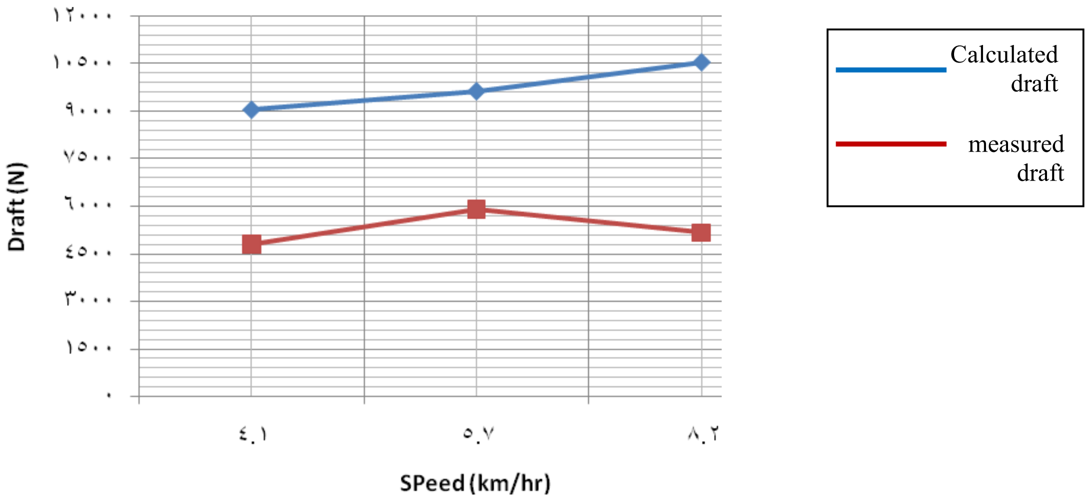


Figure (4-16) Draft Vs speed at depth (20 cm)

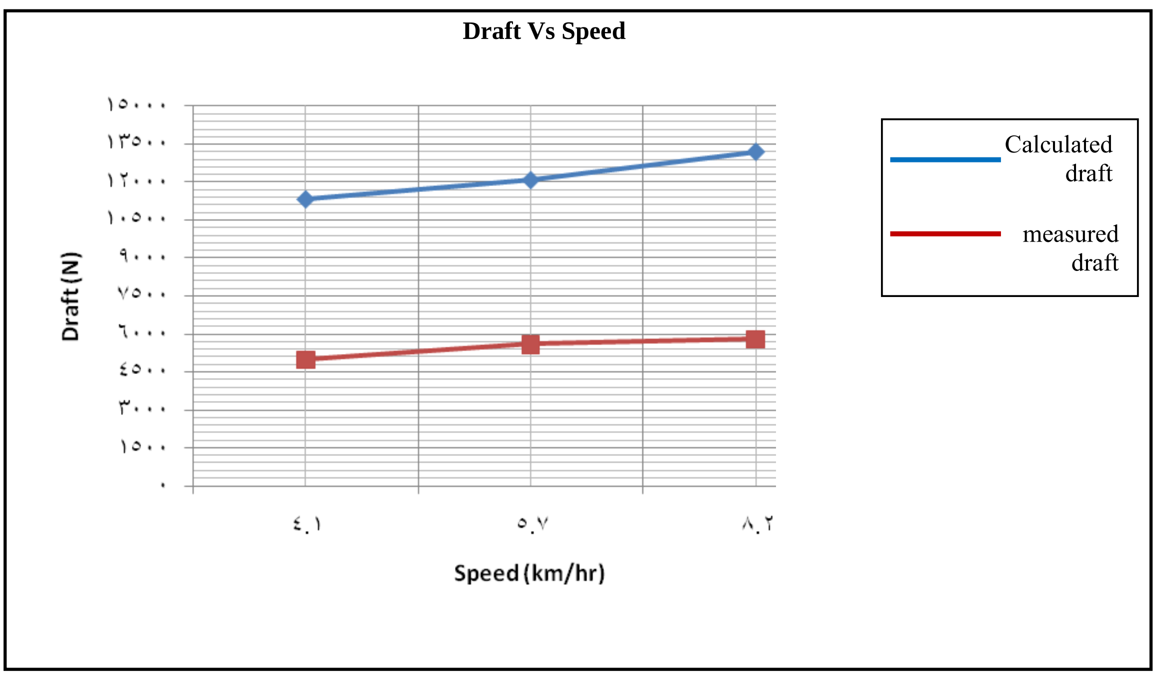


Figure (4-17) Draft Vs speed at depth (25 cm)

4-11-3 Rotary Hoe

Width (m)	Depth (cm)	Speed (Km/hr)	Calculated Draft (N)	Measured draft (N)	Calculated P_{db} (w)	Measured P_{db} (w)	Specific draft (N/cm^2)	% range of draft variation
1.50	5	4	4500	3500	5000	3888	4.6	22%
1.50	5	6	4500	7500	7500	12500	4	66%
1.50	5	8	4500	5760	10000	12800	7.6	28%

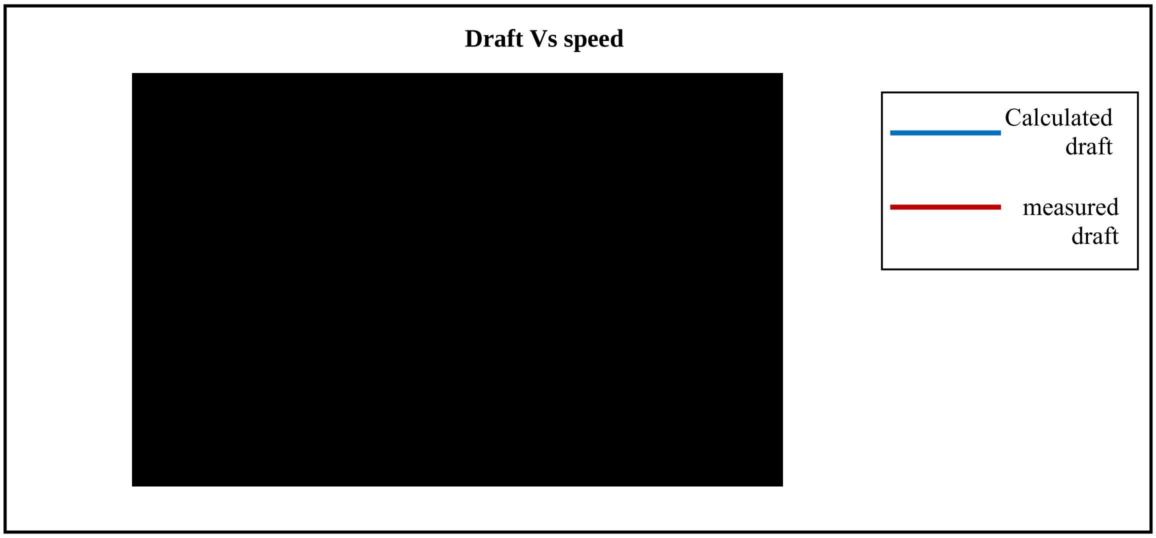


Figure (4-18) Draft Vs speed at depth (5cm)

4-12 Values of slip measured in the field for different types of tractors

4-12-1 Massy Ferguson Tractor – Model MF 290-

(Gear selected 1-H)

Slip %

Slip% = $(D_u - D_L) \times 100 / D_U$

D_U = Distance travelled with unloaded tractor.

D_L = Distance travelled with loaded tractor.

Distances traveled in 154.2 sec:

Distance traveled with unloaded tractor = 261.7 m

Distance traveled with loaded tractor = 229.2 m

Slip % = (261.7-229.2) x 100/ 261.7 = 12.4%

4-12-2 New Holland (82 hp)

Slip%:

(Gear selected 1-H)

Slip% = $(D_u - D_L) \times 100 / D_U$

D_U = Distance travelled with unloaded tractor.

D_L = Distance travelled with loaded tractor.

Distances traveled in 100 sec:

Distance traveled with unloaded tractor = 300 m

Distance traveled with loaded tractor = 249 m

Slip % = (300– 249) x 100/ 300 = 17%

Chapter (V)

Discussions & Conclusions & Recommendation

5-1 Discussions:

- The tractor used for the experiments was relatively old and much time was taken for its repair and maintenance. This attributed the low values of field efficiency calculated from the experiments.
- The difference between the values calculated and values measured for draft and drawbar power resulted from the fact that the constants taken for the ridger and disc plough were for the disc bedder and sweep respectively,

because no constants are available in the standards. These estimated constants may result in the differences shown.

5-2 Conclusions:

From these results the following conclusions were drawn :

- The measured draft and drawbar power values were found to be matching with the calculated values using ASABE equations and the error ranged from 22 to 66% Rotovator , 38 to 55% for disc plow and 7.5 to 30% for the ridger compared to what is found in standard ASABE table (+_30%, +_45% ,+ 40%) respectively.
- The value of slip for two types of tractors (tilled soil) was found within the range of ASABE standards values (12%-17%).
- The field efficiencies measured in the field for three implements (19% for ridger, 23.6%for disc plow ,51.9% for rotary hoe) were lower than the standard values (70%-85%).

5-3 Recommendations:

- Use of drawbar digital dynamometer with recording system is required.
- Considering the effect of moisture content.
- Use skilled and well trained operator to decrease time loss and increase field efficiency.
- To increase the field efficiency we recommend to repair all the machines to minimize the time loss.

- Using of modern techniques (GPS) and control traffic such as B-line method.
- Conduct experiments on different soil types.
- Use other types of tillage implements with various speeds and tillage depths other than those used in this study.

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- (William Edwards) in (May 2007)

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Chapter (I)

Appendix

Fig (3-3-1) shows the Disc plow used in the experiment

Fig (3-3-2) shows the Hitching of disc plow

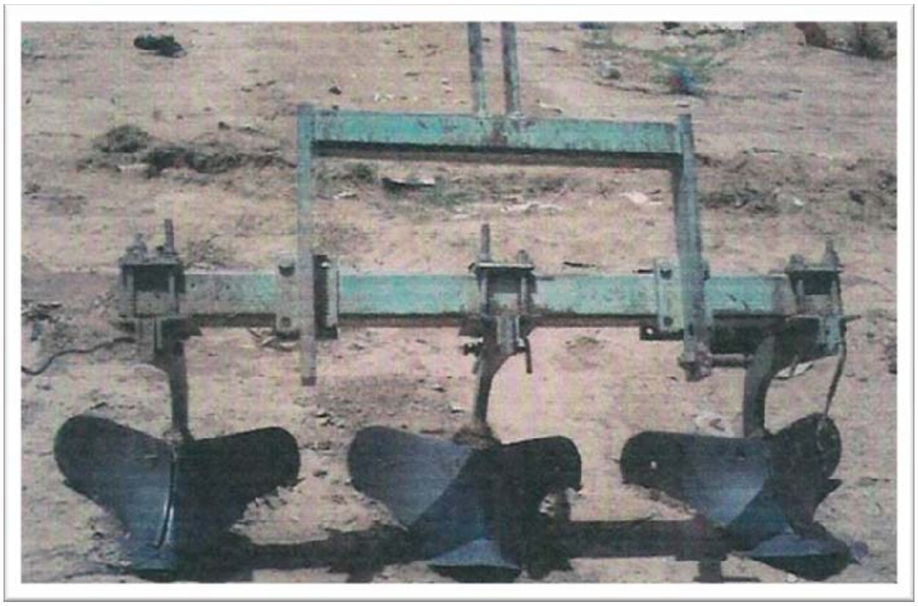

Fig (3-3-3) shows the ridger used in the experiment

Fig (3-3-4) shows the hitching of ridger

Fig (3-3-5) shows hitching of rotary hoe

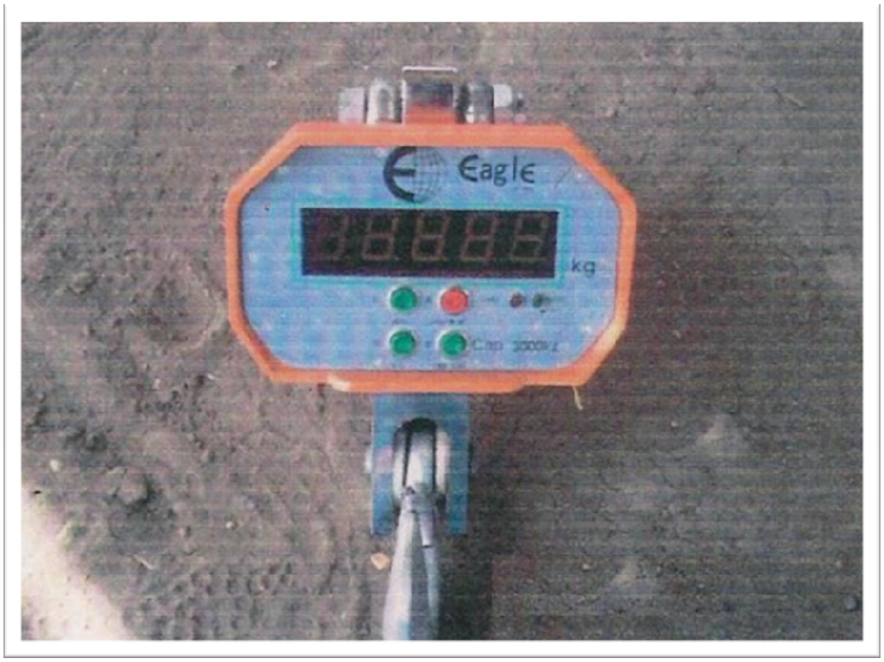

Fig (3-3-6) Shows the drawbar Digital Dynamometer

Fig (3-3-7) Shows Tractor with Implement and Dynamometer