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Research Article

Optimization of Machine Tractor Outfit - Case of Disc Plough

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Abstract

Agricultural mechanization in Ethiopia is found to be at minimum level mainly depending on draft animals and human drudgery. One of the factors affecting on tractor matching to a proper disc ploughs in different climate and soil conditions. The objective of this study was to optimize machine tractor outfit for some selected agricultural tractor with disc plough. Therefore, three models of disc plough with tractors 80 hp and 50hp on the 2nd and 3rd gears forward speeds of 1.18 m/s, 2.01m/s, 0.89 m/s, and 1.18m/s respectively was tested and ploughed in vertisol and sandy clay loam soil type. The results obtained during ploughing operation in vertisol soil type 80 hp with 4 bottom disc plough 66 cm disc diameter the field capacity, average pull force and average fuel consumption was 0.35 ha/hr, 17000N and 28 lit/ha respectively and 80 hp with 3 bottom disc plough 66 cm disc diameter the field capacity, average pull force and average fuel consumption was 0.52 ha/hr, 13500N and 21.8 lit/ha respectively. Sandy clay loam soil 80 hp with 4 bottom disc plough 66 cm disc diameter the field capacity, average pull force and average fuel consumption was 0.62 ha/hr, 11500N and 20 lit/ha respectively and 80 hp with 3 bottom disc plough 66 cm disc diameter the field capacity, average pull force and average fuel consumption was 0.52 ha/hr, 8500N and 23.08 lit/ha respectively. Sandy clay loam soil 50 hp with 3 bottom disc plough 66 cm disc diameter the field capacity, average pull force and average fuel consumption was 0.31 ha/hr 8500N and 19.2 lit/ha respectively and 50 hp with 4 bottom disc plough 50 cm disc diameter the field capacity, average pull force and average fuel consumption was 0.26 ha/hr, 7500N and 15.39 lit/ha respectively. Based on the performance evaluation results in vertisol soil type 80 hp tractor with 3 bottom disc plough 66 cm disc diameter and in sandy clay loam soil type 80 hp tractor with 4 bottom disc plough 66 cm disc diameter, 50 hp tractor with 3 bottom disc plough 66 cm disc diameter was the most appropriate for ploughing as it recorded the highest field capacity, low pull force and fuel consumption.

Key words: Disk Angles, Disk Plow Draught, Tractors, Implements, Optimization, Tillage.

1. Introduction

Agriculture has been the Main economic driving sector in Ethiopia and plays the biggest role in contributing to GDP and for the recorded changes in growth as compared to other economic sectors. Agricultural has created and is creating conducive situations which enable the transformation to industrialization. Agricultural productivity in Ethiopia is improving, there are still major gaps in productivity when compared with the rest of Africa in some crop areas, and almost universally, when compared with the global output level [1].

Tillage is to modify the state of the soil in order to provide conditions favorable to crop growth. Three things are involved in soil tillage, which are the power source (tractor or animal), the soil and the implement (Disc plough). It can be defined as any positive action when forces are reasonably applied with the aim of altering the soil conditions for agricultural purposes. Ploughing is a primary tillage operation which is performed to shatter and achieve soil inversion. It is the initial soil working operation and also the deepest tillage operation of about 150 to 300 mm. Ploughing is the most important primary tillage operation for arable farming in preparation for the production of vegetable and cereal growing crops. It creates a suitable soil condition for plant growth which increases crop productivity and boosts the agricultural economy.

Disc Plough is a tillage implement used for primary soil tillage operation. It is used in tropical region where condition is very hard and rough and totally unsuitable for use of the conventional mold board plough. Consequently, disc plough has a tilt adjuster with which the angle of tilt of the blade is adjusted. The width of cut per disc (Disc plough) depends upon the spacing and the angle (adjustable) between the gang axis and the direction of travel. It was observed that disc plough has a higher total and specific draught than other tillage implements, for a given soil type and tractor forward speed.

Draught of tillage implement (Disc plough) however plays a vital role in developing more efficient tillage system by selecting suitable combination of tractor and implements Draught is the horizontal component of pull force, parallel to line of motion, while side draught, is the horizontal component of pull, perpendicular to the line of motion. The force required to overcome the soil resistance and move the tillage implement at the required speed is called the cutting force. The horizontal component of this cutting force is called the draught. Draught is the total horizontal force parallel to the direction of travel required to propel the implement. It is the sum of the soil and crop resistant and the implement rolling resistance.

The proper selection of tractor and implement for a particular farm situation requires availability of the field performance data of both tractors and implements. Tractor and implement test are needed in different farm sites under different operating conditions to prevent serious damage. This will enable the proper selection of tractor and implement for a particular requirement.

Now, Adama Agricultural Machinery engineering Industry (AAMEI) is the biggest industry in Ethiopia which works to transform the traditional farming to mechanized farming. The industry assembles different agricultural tractors and Implements (disc ploughs). These research objectives are to investigate the draught force of a disc plough at various tractor forward speeds in different types of soil. To study the relative effect of the parameters involved with the draught of the research conducted in the area of the study and end with providing recommendations on how the uses of farm tractors with implement will be enhanced.

Many factors have contributed to agricultural mechanization. Reducing human drudgery, increasing productivity, and improving timeliness of agricultural operations such as planting and harvesting, and reducing peak labor demands are among the most compelling. A tractor pulling a plow can cultivate a larger area than a human with a spade in the same amount of time, thereby increasing productivity and timeliness. Timeliness is an important factor in agricultural production.

In Ethiopia there was a factor affecting the use and operation of agricultural tractors and implement optimization scientifically. The factor results a gap on how to use and implement agricultural machinery by considering their capacities with farm locations. There for the Ethiopian farmers face a problem on the selection of agricultural machines with implements. These problem results a frailty on their machine. Improper selections and management of machines regarding on: different types of topography, agro-ecology, lack of skilled operator, improper hitching and optimization of tractors with their implement. So, to solve the problems it is better to optimize tractor with disc plough. The main objective of the study is to optimize machine tractor outfit on some selected Agricultural tractor with disc plough.

Tractor enhances human capacity, leading to escalation and increased productivity as a result of proper seedbed preparation, timely planting by integrating functional processes. Tractor also plays a great role in weed control, harvesting, post-harvest handling and accessibility to market. Realizing this, currently the government is stepping forwarding in provision of improved technologies through various institutes and organizations. Adama Agricultural Machinery Industry is one the organization which is working towards addressing problems pertinent to provision of improved agricultural implements and machineries. One of the factors affecting the uses of tractors and implements is how to uses different types of agricultural tractors and implements in different areas.

In this study, the main objective of the test was to check which plough is suitable for which tractor horse power in the agro technical conditions of the tested area. i.e economically, agriculturally, technically, adaptability, performance capacity, efficiency and durability of the disc plough to the prevalent climatic and soil conditions. By Identify tractors horse power, Disc ploughs number of discs and measuring soil properties for the improvement of specific technologies to optimize of agricultural tractors and disc plough.

An optimization of the relationship between the field work performed, as expressed in hectare per hour, and the fuel cost is the wish of every farmer. For some farmers, field work performed will take the first priority, while other farmers will consider the reduction of fuel cost to be more important. Today, the relationship between the work done and the fuel used is solely dependent upon the experience and capability of the driver. Fig. 1 gives an example of the dependence of the work rate and the ground speed on working implement widths for different soils.

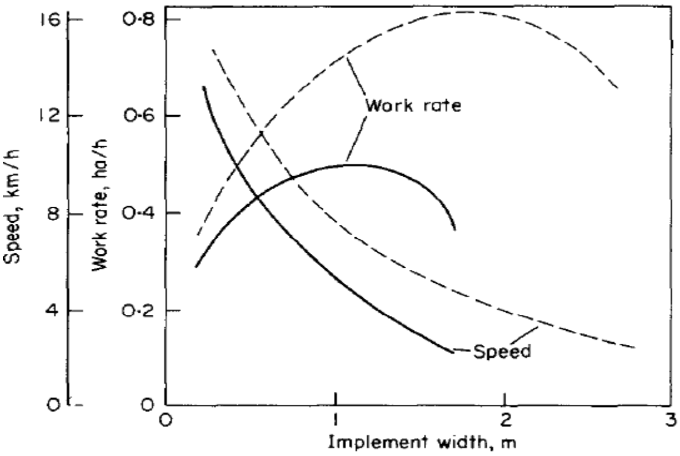

Figure 1: Work rate and ground speeds vs implement width (__ Loamy clay: --- sandy loam).

The fuel consumption of soil tillage operations varies widely and can be reduced through proper matching of tractor size, operating parameters, tillage implement. Of the average fuel consumption for ploughing (25 L ha-1), only 5 L ha-1 of the fuel energy is used for the drawing of the plough, while the remaining fuel consumption is due to efficiency losses in the engine, transmission, and wheel/soil interface. The term "fuel" is used here exclusively to denote diesel fuel. Additional, soil related, parameters, such as soil texture and organic matter content, influence fuel consumption in soil tillage.

Draught of tillage implement (Disc plough) however plays a vital role in developing more efficient tillage system by selecting suitable combination of tractor and implements. Farmers employ draught requirement data from tillage implement (Disc plough) in specific soil type to determine the matching size of tractor for operation. Draught is the horizontal component of pull force, parallel to line of motion, while side draught, is the horizontal component of pull, perpendicular to the line of motion. The force required to overcome the soil resistance and move the tillage implement at the required speed is called the cutting force. The horizontal component of this cutting force is called the draught. Draught is the total horizontal force parallel to the direction of travel required to propel the implement. It is the sum of the soil and crop resistant and the implement rolling resistance.

Nkakini, (2015) soil type and condition are the most implement factors that contribute to the draught force of agricultural implement. The draught required to pull a tillage implement (Disc plough) is basically a function of soil properties, implement width, operating speed and depth of cut at which it is pulled, moisture content and bulk density. According to some research findings, the increase in soil bulk density increased the draught forces of tillage implement (Disc plough).

One aspect of the physical properties of soil, its texture, is described by the percent of particles in various size classes. The sides of the triangle are axes, each representing the percentages of sand, silt, and clay that constitute the soil. Special names are assigned to various combinations as designated by the areas within the triangle. Thus, if a soil is composed of 40% sand, 35% silt, and 25% clay, it is called a loam. This is noted by the in the figure 2. Note that because of the importance of the surface area-to-volume ratio, soils with as little as 20% clay still are called clay soils. There are various laboratory methods of measuring the relative amounts of sand, silt, and clay.

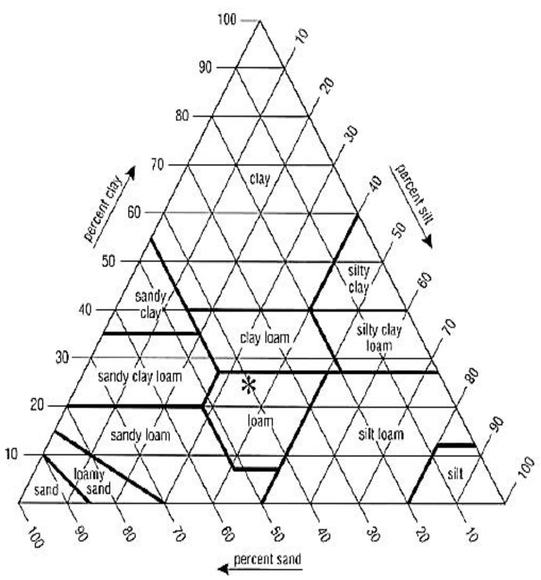

Figure 2: USDA soil texture triangles showing the percentages of sand, silt, and clay.

Note: that these percentages are after sieving out particles > 2.0 mm (gravel and stones) and removing the organic matter.

The Cone penetrometers are used to determine the resistance to penetration of a soil. The resistance of penetration (kN/cm2) of the soil now can be determined by dividing the reading value by the surface of the cone. The soil parameter for empirical prediction of tractive performance is based on the force (KN) to push a circular cone base area 322 mm2 shown in Figure 3 (a) into the soil at a constant speed 30 mm/sec (Frank, 2013). The passage of the cone into the soil is resisted by the normal and soil - metal resistance forces as suggested in Figure 3. The parameter, termed the cone index (CI) is given by,

$$Cone\ Index(Cl) = \frac{Force\ on\ cone}{Base\ area\ of\ the\ cone}, [kPa]$$

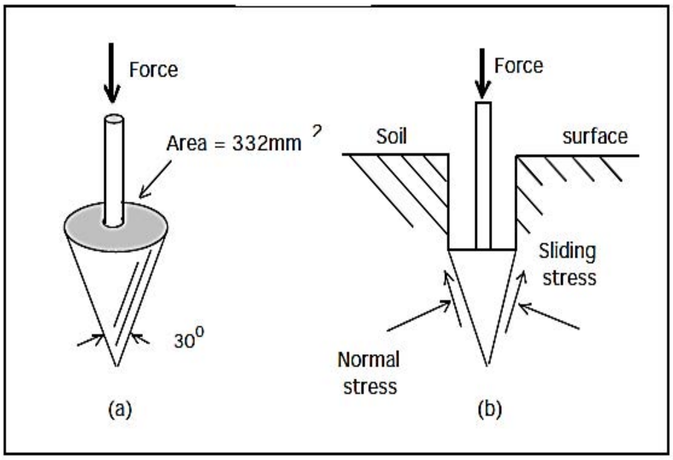

Figure 3: Cone penetrometer for measurement of soil parameter.

The affecting properties and parameters of soil on draft force and required energy include: soil moisture content, bulk density, cone-index and soil structure. These parameters as the major influencing parameters on the draft force were analyzed in a sand clay loam soil (43% clay, 29% sand and 28% silt). Penetration tests were conducted at 15 points from 0 to 20 cm deep using a manually operated penetrometer.

Table 1: Soil cone index for various surface conditions.

Surface condition	Cone Index, kPa
Dry grassland	1500
Dry stubble	1000
Wet Stubble	500
Dry loose soil	400
Wet loose soil	200

1.1. Description of the Study Site

The study site was located at Adama Agricultural Machinery Engineering Industry (AAMEI) of Metals and Engineering Corporation (METEC). The Industry located from the capital city of Ethiopia 99 km east of Addis Ababa. It's found at an elevation of 1712 m above sea level with latitude of 39.270 E and longitude of 8.540 N at Adama (Oromia Regional State). Soil type in the area is sandy clay loam. The test was conducted at Adama, and Assela. Assela is also located 76 Km south from Adama. It's found at an elevation of 2450 m above sea level with latitude of 39.070 E and longitude of 7.570 N. soil types in the area is sandy loam.

1.2. Tractor

The Poland made agricultural tractors were tested for ploughing. The tractor models are URSUS model 5014A and model 8014A shown in Appendix. The tractors were designed to do all kinds of agricultural operation with mounted; semi mounted and trailed machine and implements.

Table 2: Specification of tractor.

Dimensions	URSUS 5014A 50 hp	URSUS 8014A 80 hp
Length, mm	3900	4210
Width, mm	1890	2000
Height, mm	2640	2690
Wheel base, mm	1985	2230
Wheel Front track, mm	1285	1560
Wheel Rear track, mm	1356	1560
Ground clearance, mm	305	380
Turning radius of with inside wheel brakes, mm	3200	4470
Weight, kg	2652	3003
Rear wheel ballast weight, kg	140	210
Front wheel ballast weight, kg	100	260

1.3. Disc Plough

The China made agricultural disc ploughs were tested for ploughing. The model of disc ploughs is 1LY 320, 1LY 325 and 1LY425. The purposes are: 1. to identify disc plough model and number of disc. 2. To check the diameter of discs by measuring instrument (tap) or to calculate diameter of the disc (Dd) as stated by (Sharma 2010). To determine the parameters of the disc plow the following calculation is used.

$$D_d = \frac{Kd_p}{cos\beta}, \text{cm}$$

Where k = a coefficient which varies from 2.5-3 for deep tillage

d_p = depth of ploughing cm

β = tilt angle of disc which is 150-250-with vertical

D_d = diameter of the disc mm (cm)

Table 3: Implements and their parameters.

Model	No. disc	Disc diameter, mm	Working depth, mm	Working width, cm	Weight, kg
1LY 320	4	510	200	60	180
1LY 325	3	660	250	78	390
1LY 425	4	660	250	105	480

The plough 1LY 320, 1LY 325, and 1LY 425 were tested at AAMI, Adama and Assela. The depth of cut depends on the diameter of the blade; about one-third the blades diameter is the limit for depth and range for ploughing at a depth of 10 to 30 cm also suggested by.

1.4. Field Description and Parameters

The condition of field was affected ploughing operation. Therefore, field condition is important for ploughing operation test. The following parameters were determined before ploughing.

- Experimental Site and Design:
- Soil physical properties Determination
- Soil moisture and resistance
- Adjustment and attachment of plough
- Skill (Method of ploughing)
- Depth of ploughing
- Size of plot

1.5. Experimental Site and Design

The Experiments were conducted in the field URSUS model8014, 80hp and URSUS model5014, 50hp tractor with model 1LY 425, 325, 320-disc plough in ploughing operation forming four treatments with using Randomized Complete Block Design (RCBD). RCBD is one of the most widely used experimental designs in agricultural research. The design is especially suited for field experiments. The primary distinguishing features of the RCBD is the presence of blocks of equal size, each of which contains all the tests. Therefore, the experimental area for each testing site was 15 m by 100 m and was designed with four different strips 100 m by 3 m wide with a space of 1 m between each strip. The data was analyzed in result and discussion section.

Figure 4: RCBD plot size sample representation- Tested field.

1.6. Determination of Soil Moisture Content

The samples were collected at a depth of soil surface before operations for determination of moisture content. The soil moisture was determined by oven dry method. Three samples were collected randomly from the test plots. The samples were kept in oven for 24 hours at temperature of 105°C. The samples were weighed before and after drying. The moisture content (Dry basis) was determined by the following formula.

$$Moisture\ content\ (\%) = \frac{W_w - W_d}{W_w} \times 100$$

Where, Ww= Weight of wet soil sample, and Wd = Weight of dry soil sample

1.7. Measuring Soil Resistance

The samples were collected from 10, 20 and 30 cm depth of soil surface for measuring of soil resistance. The soil resistance was measured by Cone penetrometer from 10, 20 and 30cm depth of soil surface. Thirty samples were measured randomly from the test plots. Cone penetrometer testing involves pushing a cone into the soil at a certain rate and recording the resisting force exerted by the soil on the penetrometer. The force required divided by the area of the base of the cone.

The spring type dynamometer was measured the tractor drawbar pull. The dynamometer system for the test and evaluation were transferred to the field. The stop watch was used to measure the time for the test ploughing operation. The outfit was let to work on the plot. The time was recorded using hand watch. The steel rule and meter were used to measure the depth of cut and the width of cut. The depths of cut were measured with a steel tape, from the bottom of the furrow to the surface level of the soil at randomly selected points.

Figure 5: measuring soil resistance by cone penetrometer

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Figure 6: A dynamometer to measure the drawbar force

Fuel apparatus a separate apparatus was used to measure fuel consumption. It consisted of a secondary tank of 5 liters capacity attached to the primary fuel filter of the tractor. The fuel consumption was measured as per the standard method by observing the fuel required for traveling 100m long distance. The volume of fuel used was considered as fuel consumed for a particular time period. Fuel consumption during the test was measured by topping the 5-liter container at start of each run there topping at the end of specific run using measuring can. The similar measurements reported by.

Fuel consumption rate: The fuel consumption rates are determined as follow [2].

$$FCR = CR/A$$

Where: FCR = fuel consumption rate (L / ha); CR = reading of cylinder (L); A = plot area (ha)

URSUS 5014A and URSUS 8014A Models Tractor Drawbar Pull and Speed: From URSUS operational manual, the drawbar force of tractor URSUS 5014A and URSUS 8014A tractors are listed Table 4 and 5.

Table 4: Draw bar force and speed on URSUS 5014A, 50hp.

Gears	Draw bar force k.gf	Speed km/h
I	870	2.5
II	870	3.2
III	870	4.26
IV	870	7.24
V	560	8.9
VI	420	15.23
VII	300	17.95
VIII	300	30
Revers I	-	3.98
Revers II	-	8.97

Table 5: Draw bar force and speed on URSUS 8014A, 80hp.

Gears	Draw bar force k.gf	Speed km/h
I	1400	2.50
II	1400	4.26
III	1400	7.24
IV	1400	8.90
V	1150	10.54
VI	950	15.15
VII	750	17.95
VIII	600	30.0
Revers I	-	5.26
Revers II	-	8.97

1.8. Adjustment of Plough

Adjustment of all the plough bottoms for depth of cut is affected by means of the top link and right hand drop link of the hitch. The horizontal position of the plough frame is an indication of the proper travel of the plough. If the front plough bottom cuts deeper than the rear one increase the length of the top link if the rear plough bottom is set deeper shorten the top link. The depth of working is adjusted by changing the height of the position of the plough ground engaging wheel. Fix the top link at the top hole in the shackle to enable operation of the sensor in a wide range of the depth of cut. If the top hole setting fails to give the required (great) depth of cut, fix top link at the middle hole or, if necessary at the lower one. The width if the plough cut is adjusted by changing the position of the plough hanger axle.

1.9. Draught Force

The drawbar pulls (draught force) was determined using trace-tractor techniques. Dynamometer was attached to the front of the tractor mounted with implement. Another auxiliary tractor was used to pull the implement mounted tractor through the dynamometer both in their transportation positions and tillage operating positions for ploughing. The average drawbar-pull (Draught to pull the implement) is the difference between the towing force, while in neutral gear without implement in tillage operation and the towing force while the implement is in tillage operation respectively.

By Equation is used in determining the draught force.

$P = P_2 - P_1$

Where, P = draught force, P_1 = the force required to pull the implement in transportation position, P_2 = the force required to pull the Implement during tillage operation.

Calculation of drawbar horse power (DBHP) is stated by.

DBHP = 60% of BHP (Brake horse power)

$$DBHP = \frac{draft(kg) \times speed(m/min)}{4500}$$

Draft of plough= n Wc.dp.k. f [kg]

Where n = number of bottoms or disc in plough; W_c = width of cut in cm; d_p = depth of ploughing in cm; k = a constant for heavy soils k=0.75-0.85 kg/cm^2; f = factor of safety (FOS) = 1.5; DBHP = Draw bar horse power ($kg.m/min$)

1.10. Measurement of Field Performance

Theoretical field capacity: Theoretical field capacity is the rate of work when the implement uses its full width and time and it was calculated as follow [2-4]

$$TFC = \frac{W \times S}{C}$$

Where: TFC = Theoretical field capacity (ha/h); S = Working speed (km/h); W = cutting width of implement (m); C = Conversion factor = (10)

Effective field capacity: Effective field capacity is the actual rate of work and it was calculated as follow:

$$EFC = \frac{A}{T}$$

Where: EFC = effective field capacity (ha/h); A = hectare; T = hour.

Field efficiency: Field efficiency was calculated as follow:

$$FE(\%) = \frac{EFC}{TFC} \times 100$$

Rear wheel slippage: The rear wheel slippage was determined as follows:

$$S = \frac{D_u - D_l}{D_u}$$

Where: S = rear wheel slippage (%); Du = distance travelled by unloaded tractor; Dl = distance travelled by loaded tractor

2. Results and Discussion

Soil Resistance and Moisture Content of Soil: During carrying out the experiments, the soil conditions of the experimental field were studied and different parameters were calculated (Table 6 and 7). The soil of the field was vertisol and sandy clay loam soil. Moisture content on dry basis of soil was measured by oven dry method. Five soil samples were taken randomly at five different locations in the plot using core sampler of 8.0 cm diameter and 12 cm height.

Table 6: Soil moisture content in the field test (Adama Agricultural Machinery Industry, Adama).

Observation	Weight (gram)	Weight after oven dried (gram)	Moisture content (% W_b)
1	525	425	19.04
2	510	413	19.01
3	512	415	18.94
4	502	399	20.52
5	563	455	19.18
Average	522.4	421.4	19.33

According to table 6, moisture content on dry basis of soil was measured by oven dry method. Soil type sandy clay loam moisture content at 5 different places was found to be 19.04 %, 19.01%, 18.94 %, 20.52 % and 19.18 % on wet basis respectively. The average moisture content of the experimental field was 19.33%.

Table 7: Soil moisture content in the field test (Kulumsa Agricultural Mechanization Center, Assela).

Observation	Weight of a soil (gram)	Weight after oven dried (gram)	Moisture content(% W_b)
1	160	107	33.13
2	183	124	32.24
3	162	108	33.33
4	194	133	31.44
5	178	118	33.71
Average	175.4	118.20	32.77

Table 7, presented the data obtained at Assela, the test field was vertisol (black soil). According to table 7, in the tests period of the soil moisture content at 5 different places was found to be 33.13%, 32.24%, 33.33%, 31.44% and 343.71% on wet basis respectively. The average moisture content of the experimental field was 32.77%.

Table 8: Soil resistance in field test (Adama Agricultural Machinery Industry, Adama).

Soil resistance Cone penetrometer measurement in Adama Average penetrometer reading kN/cm^2				
Month	Depth cm			
	10	20	30	Average
1	0.380	0.420	0.480	0.430
2	0.420	0.350	0.420	0.360
3	0.340	0.460	0.450	0.420
4	0.250	0.310	0.290	0.280
5	0.240	0.260	0.390	0.300
6	0.250	0.380	0.390	0.350
7	0.320	0.290	0.350	0.320
8	0.280	0.350	0.480	0.430
9	0.360	0.400	0.450	0.400
10	0.320	0.410	0.490	0.460
Average	0.316	0.363	0.419	0.366

According to table 8, Soil resistance from field test at Adama the average cone index of the soil which is found at around Adama was 0.37kN/cm^2. This index value indicates that the soil property in the respective site become wet loose soil. Stated that the value of cone index of wet loose soil was in the range of 0.2 to 0.4kN/cm^2. Therefore, Adama soil type lies in stated range. According to table 9, Soil resistance from field test at Assela the average cone index of the soil which is found at around Assela was 0.89kN/cm^2. This index value indicates that the soil property in the respective site become dry stubble soil. Stated that the value of cone index of dry stubble soil was in the range of 0.5 to 1 kN/cm^2. Therefore, Assela soil type lies in stated range.

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Table 9: Soil resistance in the field test (Kulumsa Agricultural Mechanization Center, Assela).

Soil resistance				
Cone penetrometer measurement in Assela, Kulumsa				
Average penetrometer reading kN/cm^2				
Month	Depth cm			
	10	20	30	Average
1	0.450	0.540	0.650	0.550
2	0.320	0.480	0.540	0.460
3	0.310	0.480	0.510	0.430
4	0.410	0.540	0.720	0.560
5	0.470	0.390	1.650	0.840
6	0.380	0.450	0.620	0.480
7	0.640	0.870	1.720	1.080
8	1.320	1.490	1.490	1.430
9	1.420	0.900	1.420	1.250
10	1.430	1.670	2.470	1.860
Average	0.718	0.781	1.179	0.894

2.1. Power Test and Field Test of URSUS 8014A Tractor at Assela

URSUS 8014A model tractor with 260kg front weight and 210kg rear weight. The tractors URSUS model 8014A were tested with various disc ploughs in order to analyze their efficiency in ploughing operation and places having different altitude and soil conditions shows in bellows Table 10 and 11.

Table 10: Power using tractors URSUS model 8014A in the field test, (Kulumsa Agricultural Mechanization Center, Assela).

Operation	Ploughing			
Plough	1LY 425		1LY325	
Gear comb.	2nd	3rd	2nd	3rd
Working depth (cm)	25	25	25	25
Working width (cm)	102	102	78	78
Distance covered by 10 rev. of rear wheels during transport (m)	44	44	44	44
Distance covered by 10 rev. of rear wheels during ploughing (m)	33	30	41	39
Ploughing force (dyna. Reading) (N)	15000	1700	11500	13500
Slippage (%)	25	31.8	6.82	11.36

According to Table 10 and 11, The test results obtained during ploughing operation in vertisol soil type 80hp with 4 bottom 66 cm disc diameter disc plough the average performance of the plough output was 0.35 hectares per hour and the fuel consumption is liters per hectare or 9.63 liters/hr and the force required to pull the plough ranges from 15,000N to 17,000N the result was above the pulling capacity of the tractor. The output (productivity) of the plough in 8 hours of operational time is 2.8 hectares and the fuel consumption is 78.4 liters. The fuel consumption per hector was very high and it makes it uneconomical. This output was found when the tractor was going with a speed of 5.5 km/hr.

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Table 11: Field test data collected at Assela URSUS 8014A.

Tractor Used	Model	URSUS 8014A	
Plow used	Front weight added	260kg	
	Model	1LY 425	1LY 325
	Type	Disc	Disc
	No of bottoms	4	3
	Theoretical working width (cm)	1.05	0.78
	Average working depth (cm)	25	25
Results of field test	Soil type	Vertisol	
	Moisture content of soil, %	32.77	
	Soil resistance, kN/cm2	0.89	
	length of plot (m)	100	100
	Time taken (s)	106	55
	Fuel (L)	0.28	0.17
	Working speed (km/hr)	5.5	6.73
	Actual speed (km/ hr)	3.4	5.07
	Actual Field capacity (ha/hr)	0.35	0.52
	Theoretical field capacity (ha/hr)	0.56	0.69
	Efficiency (%)	62.5	73.91
	Specific fuel Consumption (SFC),		
	SFC (Lit/hr)	9.63	14.07
	SFC (Lit/ha)	28	21.8

The manufacturer's figure of productivity at this speed is 0.5 ha/hr. of operational time. There for in places of high altitude and vertisol soil type in 80 hp tractor cannot be used for 4 bottom 66 cm disc diameter disc ploughing. The calculation is shown in appendix E and F. Ploughing operation in vertisol soil type 80 hp with 3 bottom 66 cm disc diameter disc plough, the output was 0.52 ha/hr. i.e. 4.16 hectares in 8 hours of operational time and the fuel consumption was 14.07 liters/ hr or 21.8 liters per hectare and the force required to pull the plough ranges from 11500N to 13500N which is within the pulling capacity of the tractor. The performance output was 0.52 ha/hr and this was above the recommended output. So, the plough model 1LY 325 3 bottom disc plow has a good efficiency.

2.2. Power Test and Field Test URSUS 8014A Tractor at Adama Site

URSUS 8014A model tractor with 260kg front weight and 210kg rear weight. The tractors URSUS model 8014A were tested with model 1LY425 and model 1LY 325-disc ploughs in order to analyze their efficiency in ploughing operation in places of Adama Agricultural Machinery Industry, Adama table 12 and 13.

Citation: *Ghebrekidan, B.Z., Koroso, A. W., Olaniyan, A. M. (2024). Optimization of Machine Tractor Outfit - Case of Disc Plough. Journal of Agriculture and Education Research 2 (2). 1-15.*

Table 12: Power test data collected at Adama site URSUS 8014A.

Operation	Ploughing			
Plough	1LY 425		1LY325	
Gear combination	2nd	3rd	2nd	3rd
Working depth (cm)	25	25	25	25
Working width (cm)	105	105	78	78
Distance covered by 10 rev. of rear wheels during transport (m)	44	44	44	44
Distance covered by 10 rev. of rear wheels during ploughing (m)	42	41	43	42
Ploughing force (dyna. Reading) (N)	8500	11500	6000	8500
Slippage (%)	4.6	6.8	2.3	4.6

Table 13: Field test data collected at Adama site URSUS 8014A.

Tractor	Model	URSUS 8014A	
Plow used	Front weight added	260kg	
	Model	1LY 425	1LY 325
	Type	Disc	Disc
	No of bottoms	4	3
	Theoretical working width (cm)	105	78
	Average working depth (cm)	23	23
Results of field test	Soil type	Clay sandy loam	
	Moisture content of soil, %	19.07	
	Soil resistance, kN/cm^2	0.37	
	length of plot (m)	100	100
	Time taken (s)	60	55
	Fuel (L)	0.21	0.18
	Working speed (km/hr)	6.82	5.72
	Theoretical speed (km/ hr)	7.0	9.3
	Actual Field capacity (ha/hr)	0.62	0.52
	Theoretical field capacity (ha/hr)	0.74	0.73
	Efficiency (%)	83.78	71.23
	Specific fuel Consumption (SFC),		
	SFC (Lit/hr)	14.0	10.0
	SFC (Lit/ha)	20.0	23.08

According to Table 12 and 13, the test results obtained during ploughing operation in clay sandy loam soil type 80 hp with 4 bottom 66 cm disc diameter disc plough the average performance of the plough in net operational time was 0.62 hectares per hour and the fuel consumption was 20 liters per hectare or 14 liters/hr. The output (productivity) of the plough in 8 hours of operational time is 4.96 hectares and the fuel consumption were 99.2 liters and the force required to pull the plough ranges from 11,500N to 14,000N which is within the recommended pulling capacity of the tractor. This output was found when the tractor was going with a speed of 6.73 km/hr. The manufacturer's figure of productivity at this speed was 0.60 ha/hr. of operational time. It can be seen that the actual value is greater by 3% than the manufacturer's recommendation. The fuel consumption per hectare was balanced and it makes it economical.

Citation: Ghebrekidan, B.Z., Koroso, A. W., Olaniyan, A. M. (2024). Optimization of Machine Tractor Outfit - Case of Disc Plough. Journal of Agriculture and Education Research 2 (2). 1-15.

The test results obtained during ploughing operation in clay sandy loam soil type 80 hp with 3 bottom 66 cm disc diameter disc plough the output was 0.52 ha/hr. such as, 4.16 hectares in 8 hours of operational time and the fuel consumption was 10 liters/ hr or 23.8 liters per hectare. Which is given as 0.54 ha/hr and the force required pulling the plough ranges from 5500N to 7500N which is within the recommended pulling capacity of the tractor. The operational time in the manufacturer's figure of productivity is 0.60 ha/hr this was above the recommended output and the fuel consumption per hectare is balanced and it makes it economical.

The plough model 1LY 425 and 1LY 325 in Adama both are above the acceptable efficiency. The fuel consumption in the plowing operation listed above was obtained in the recommended range. When it is calculated on the bases of one hector it can be seen from the above data that to pull the plow of the tractor has a good efficiency and above the recommended output.

2.3. Power Test and Field Test URSUS 5014A Tractor at (AAMI, Adama) Site Tractor; URSUS 5014A

The tractors URSUS model 5014A were tested with model 1LY325 and model 1LY 320-disc ploughs in order to analyze their efficiency in ploughing operation in places of Adama Agricultural Machinery Industry, Adama table 14 and 15.

Table 14: Power test data collected at AAMI, Adama site URSUS 5014A.

Operation	Ploughing			
Plough	1LY 325		1LY320	
Gear combination	2nd	3rd	2nd	3rd
Working depth (cm)	20	20	20	20
Working width (cm)	78	78	60	60
Distance covered by 10 rev. of rear wheels during transport (m)	39	39	39	39
Distance covered by 10 rev. of rear wheels during ploughing (m)	34	32	35	34
Ploughing force (dyna. Reading) (N)	7250	8500	5500	7500
Slippage (%)	12.82	17.95	10.26	12.82

Table 15: Field test data collected at AAMI, Adama site URSUS 5014A.

Tractor	Model	URSUS 8014A	
Plow used	Front weight added	260kg	
	Model	1LY 325	1LY 320
	Type	Disc	Disc
	No of bottoms	3	4
	Theoretical working width (cm)	78	60
	Average working depth (cm)	20	17
Results of field test	Soil type	Clay sandy loam	
	Moisture content of soil, %	19.07	
	Soil resistance, kN/cm2	0.37	
	length of plot (m)	100	100
	Time taken (s)	90	80
	Fuel (L)	0.15	0.12
	Working speed (km/hr)	4.26	4.26
	Theoretical speed (km/ hr)	6.0	7.3
	Actual Field capacity (ha/hr)	0.29	0.26
	Theoretical field capacity (ha/hr)	0.33	0.31
	Efficiency (%)	87.87	83.87
	Specific fuel Consumption (SFC),		
	SFC (Lit/hr)	5.92	10.20
	SFC (Lit/ha)	19.20	20.0

According to Table 14 and 15, the test results obtained during ploughing operation in clay sandy loam soil type 50 hp with 3 bottom 66 cm disc diameter disc plough the average performance of the plough in net operational time is 0.29 hectares per hour and the fuel consumption is 19.2 liters per hectare or 5.92 liters/hr. The output (productivity) of the plough in 8 hours of operational time is 2.48 hectares and the fuel consumption is 47.62 liters and the force required to pull the plough ranges from 7250N to 8500N which is within the recommended pulling capacity of the tractor. This output was found when the tractor was going with a speed of 4.26 km/hr. The manufacturer's figure of productivity at this speed is 0.30 ha/hr. of operational time. It can be seen that the actual value was almost near to the manufacturer's recommendation and the fuel consumption per hectare is balanced and it makes it economical.

The test results obtained during ploughing operation in clay sandy loam soil type 80 hp with 4 bottom 50 cm disc diameter disc plough the average performance of the plough the output was 0.26 ha/hr i.e. 2.08 hectares in 8 hours of operational time and the fuel consumption was 4.20 liters/ hr or 15.39 liters per hectare and the force required to pull the plough ranges from 7200N to 8500N which is within the recommended pulling capacity of the tractor; Which is given as 0.26 ha/hr of operational time. It can be seen that the actual value was near to the manufacturer's recommendation. The fuel consumption per hectare was balanced and it makes it economical.

The plough model 1LY 325 and 1LY 320 in AAMI, Adama both are above the acceptable efficiency. The fuel consumption in the plowing operation listed above was lies in the acceptable range. When it is calculated on the bases of one hector it can be seen from the above data that to pull the plow of the tractor has a good efficiency and the fuel consumption per hectare was balanced and it makes it economical.

3. Conclusions

This research focused on the optimization of three models of disc plough with tractors 80hp and 50hp ploughing operation on clay sandy loam soil at AAMI, Adama and vertisol soil at Assela for disc ploughing with 3 disc bottom and 4 disc bottom of 66cm disc diameter and 4 disc bottom of 50cm disc diameter disc plough and tractors of 50 and 80hp. Were tested with two different driving gear of 2nd and 3rd on an experimental plot of soil moisture on vertisol soil at Assela 32.77%, Soil resistance 0.894 kN/cm2 and the soil so having sticking nature it needs more power for ploughing. On clay sandy loam soil at AAMI, Adama 19.07 %, Soil resistance 0.37 kN/cm2 which does not have sticking nature and where the soil resistance is less. The plowing operation insures easy at different tractor forward speeds were conducted using dynamo meter. The ploughs have been tested for their adaptability, performance, capacity and places having different altitude, climates and soil condition. All required observation on operation and consumption of fuel were taken in both test sites.

Based on the performance evaluation results in vertisol soil type 80hp tractor with 3 bottom disc plough, 66cm disc diameter, whereas; in sandy loam soil type testing site 80hp tractor with 4 bottom disc plough, 66cm disc diameter, and 50hp tractor with 3 bottom disc plough, 66cm disc diameter was the most appropriate for ploughing with the disc plough as it recorded the highest field capacity, low pull force and fuel consumption.

3.1. Appendix: Specification

Table 16: Specification of disc plough.

Model	No of disc	Diameter of disc (mm)	Working Width (mm)	Weight of plough (kg)	Required HP
1LY 320	4	500	600	180	50
1LY 325	3	660	750	430	50
1LY 425	4	660	1050	530	80

Table 17: Specification of tractors.

	Tractor model	
	URSUS 5014A	**URSUS 8014A**
Engine make	IMR DM33T	MWM International MAXXFORCE4.1A
Power output (kw/hp) at rpm	34.5/47 @2250	62 / 83/ 2200
Maximum torque, Nm at rpm	162 @1350	285/1400
Maximum speed, km/h	30	30
Clutch	Two-disc dry type	Two-disc dry type
Gear box	12 x12 with mech. shuttle	12 x 12 with synesthete
Rear axel	w/mechanical diff. lock	w/mechanical diff. lock
Front axel	w/planetary hub	w/planetary hub
Transmition	4WD	4WD
Lifting capacity, kg	1500	2600
Front /Rear wheels	8.3-20/12.4-28	11.2-24/16.9-38
Length, mm	3900	4210
Width. Mm	1890	2000
Height, mm	2640	2690
Wheel base, mm	1980	2330
Ground clearance, mm	315	380
Weight without ballast, kg	2652	3003
Front weight (options), kg	100	440

3.2. Recommendations

Making the test period it was not possible to cover the expected hectare of output from each plough. Climatic factors also hindered the test from using this period effectively. However, in spite of these difficulties the main objectives of the test were realized during this given period. For future work it is possible to identify a lot of problems in relation to the different tractors and implement deployed in the study areas. In this research it was able to identify 80 and 50hp tractors with 3 and 4 bottom disc plows, but it researches address only very small portion of the problems existing on different areas. This research can be extended based on different types of soil and tractor horse power in tractor-implement optimize!

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