https://doi.org/10.33472/AFJBS.6.5.2024. 4501-4521

AfricanJournalofBiological Sciences

Strategic Selection of Tractors-implements pairing by using the Decision Support system at WonjiShoa Factory Ethiopia

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Article History
Volume 6, Issue 5, 2024
Received: 11 May 2024
Accepted: 17 May 2024
doi:*10.33472/AFJBS.6.5.2024. 4501-4521*

Abstract

The selection of tractors and their paired implements in the WonjiShoa factory (Ethiopia) has now become very difficult because of the diversity of tractormodels ranging from 45 to 298 kW. To dazed the problem of a paring of tractor implement the system, an expert system modelingmethodology foremost to decision support system (DSS) was accepted to make the step-wise decision. The use of DSS was validated in the study to pair an implementto match the tractor under different soiltypes, conditions, and operating constraints. Finally, the software calculates the PTO power requirement of a paired tractor. Centered onpremeditated PTO power, the software proposes accessible brands and models of tractor machinery following the gathered data bank. Model sensitivity was checked by changing the variables of the model input, which resulted in a change in power requirement. The developed DSS resulted in the economical saving of 108 USD/ha fuel cost and 11 USD/ha lubrication cost respectively for all tillage field operations. Thus, DSS can be used effectively in pairingatractorandanimplementofa particularsizefromvariousmakesandmodelsofcommerciallyavailabletractorsandimplements.

Keywords: *Tractor and implements, decision support system, Power Utilization Ratio, Cost.*

1. INTRODUCTION

Ethiopia's landholdings are fragmented into small parcels, and the average farm size of less than one hectare is expected to decrease further. According to official data on landholding size in Ethiopia's Regional States, 38% of households have less than 0.5 hectares of land, 23.65% have 0.51 to 1.0 hectares, 24% have 1 to 2 hectares, and 14% have more than 2 hectares (Diriba, 2020). The majority of tractors found in Ethiopia are imported from different countries. In 2021, Ethiopia acquired $78.9 million in tractors, making it the world's 89th-highest importer. In the same year, tractors were Ethiopia's 25th most imported goods. Ethiopia predominantly imports tractors from China ($31.9 million), the United Kingdom ($24.5 million), Italy ($5.53 million), Brazil ($5.23 million), and Spain ($4.99 million). Between 2020 and 2021, Ethiopia's fastest-growing import markets for tractors were China ($22.4 million), Brazil ($3.62 million), and the United Kingdom ($1.61 million**)** (MoTRI, 2023). The major users of tractors in Ethiopia are state-led agro-industries and farm associations.

To optimize production and boost profitability, the competitive agricultural market of today requires better utilization of resources and reduced operational costs. Machinery expenditures are the main expense in any modern agricultural production system. The optimal farm power machinery components are obtained by combining the amount of tractor power needed for a field activity, the implement size, and the number of tractors required to finalize field operations at the best time. This combination results in farm machinery with increased performance efficiency, which may result in significant cost reduction. The key parameters to choose the best tractor capacity include identifying the main field activityof a machine with the highest draught force, estimating the amount of time available to complete the prioritized task, calculating the rate of work (ha/hr), calculating the size of the implement needed, calculating the soil resistance, estimating the required power at the drawbar and calculating the PTO power.**(**Oduma*et al.*, 2019).A method for estimating tractorperformance using drawbar performance for 4 WD tractors was described by(Al-Hamed *et al*., 1994).Farmers frequently engage in the matching process unconsciously, according to. While this method frequently yields outcomes that are satisfactory in many situations, there is always space for improvement. They concluded that the proper sizing of the machinery should lead to improved operational efficiency, lower operating costs, and the best possible use of capital for fixed expenditures. A computer model usinga DSS for farm mechanization using a Geographical Information System was proposed by (Saurez de Cepeda *et al*., 2005, and Kolhe*et al* 2024) and covered natural variables like geography and crops. Decision support systems are characterized by computer-oriented tools that assist decision-makers in using data and models to recognize issues and come to conclusions. In semi-controlled or uncontrolled processes, DSS is intended to support managers. Instead of focusing on choice efficiency, they seek to increase decision effectiveness. Spreadsheets were used by (Grisso and Perumpral, 2006) to match tractors and equipment. As per ASABE Standard D 497.5, they forecast tractor performance and implement draft, respectively. Finally; theycame to the conclusion that a spreadsheet could be used to calculate field capacity, optimize weight distribution for maximum power delivery efficiency, and calculate fuel consumption.

Recent increases in fuel prices and declines in farm profitability have reignited interest in choosing and matching tractor-implement systems that deliver the highest level of energy input efficiency. The tractor and its corresponding equipment play a significant role in the management of the machinery which will ultimately result in fuel efficiency in tractors.

In WonjiShoa Sugar Factory there are more than 10different makes and models of tractors with power ratings ranging from 60 to 400 hp. Data from active tractors and implements were used to support the majority of established DSS, which forecast machinery performancebystandards **(**Saurez de Cepeda *et al*., 2005; Grisso and Perumpral, 2006; Singh *et al*., 2008; Sahu and Rahman, 2008).Programs must be created to aid farmers and managers in making the correct decision for the choice and use of farm machinery and to optimize the usage cost of various operations. A small number of studies in industrialized nations focused most of the efforts on creating a suitable method that matchesfarm tractors to their implements based on anticipated power requirements and availability of power while considering actual field conditions, soil types, and equipment conditions into consideration

Therefore, the objective of the current study is to develop a computer system modelto make decisions for the selection of tractors for different field activities at WonjiShoa sugar factory byusing Visual Basic as the programming language and Microsoft Excel as the database.

After obtaining the baseline information regarding the type of soil, travel speed, the type of field activity, draft force, implement width, and estimated field efficiency tractor power requirements for various field activitiescan be estimated (Jain and Philip, 2003, Kolhe et al. 2024).If an extremely powerful tractor is bought and then sits unused, costs money in depreciation and interest. A low-power tractor, on the other hand, cannot finish the field activity at the intended time.Therefore, it is advised that while determining the power of a tractor, the field activity that is urgent to complete requires the maximum tractor power should be considered.It is either a primary tillage operation i.e., subsoiling, or a secondary tillage activityi.e., sowing which needs the highest tractor power(Rasoul*et al*., 2013, Kolhe2009)**.**

2. HypotheticalFramework

2.1 Tractorpower requirement

After obtaining the baseline information regarding the type of soil, travel speed, the type of field activity, draft force, implement width, and estimated field efficiency for tractor power requirements for various field activities can be estimated (Jain and Philip, 2003). If an extremely powerful tractor is bought and then sits unused, costs money in depreciation and interest. A low-power tractor, on the other hand, cannot finish the field activity at the intended time.Therefore, it is advised that while determining the power of a tractor, the field activity that is urgent to complete requires the maximum tractor power should be considered.It is either a primary tillage operation i.e. subsoiling, or a secondary tillage activity i.e. sowing which needs the highest tractor power (Rasoul*et al*., 2013)

In various soil types and conditions, the soil resistance varies. A tractor that can complete all tasks in a given amount of time for a field of a certain size in light soil might not do so in relatively heavier soil for the same amount of farm field. Additionally, heavier soil attains tilth later than lighter soil, resulting in fewer total working hours being available for heavier soil overall throughout any given season. Table 1 shows travel speed, draft force, and estimated field efficiency for various implements and pieces of equipment for various field activities in various

Table1. Field efficiency, recommendedtravel speed anddraftfor various implement

Implement/Equipment	**Draft (kN/m)**	**Typical speed(km/hr)**	**Field efficiency**
MoldBoardPlough(200mm depth)			
HeavyClaySoil	15.70	4.50	80.00
Heavy Soil	13.73	5.00	80.00
MediumSoil	10.30	5.00	80.00
LightSoil	6.87	6.00	80.00
One-WayDiscPlough			
Heavy Soil	5.90	6.00	80.00
MediumSoil	4.41	6.00	80.00
LightSoil	2.94	6.00	80.00
OffsetorHeavyTandemDiscHarrow			
Heavy Soil	5.90	6.00	80.00
MediumSoil	4.91	6.00	80.00
LightSoil	3.73	6.00	80.00
DuckFootCultivator			
Heavy Soil	4.41	6.00	80.00
MediumSoil	2.94	6.00	80.00
LightSoil	1.47	6.00	80.00
SeedDrill			
Heavy Soil	1.47	5.00	70.00
MediumSoil	0.88	5.00	70.00
LightSoil	0.49	5.00	70.00
Planter			
HeavyClaySoil	1.47	5.00	70.00
MediumSoil	1.72	5.00	70.00
LightSoil	1.77	5.00	70.00

Source: (Jain and Philip, 2003)

The time available for finishing an individual field operation is also importantin decidingthe power range of atractor. If morethan one crop is to be reserved in a year, thenthe time accessible afterward harvesting of one crop and seedbedgrounding for the second crop is to be planned preciselybased on past few years' archives**.** Available working hoursdepend on timeliness, labor, transference, upkeep,and refueling. There should be provision to allow time towagon and fill seed and compost and refuel, etc. Inadditionto the above, the field efficiency of the tractor implement pairingis depicted in Table1which meansonly70-80 % effective time is used in field usage andthe rest is used for buildingcapeturns, substantialprocesses,turningandcuttingoutcurves,creatingchanges,fluctuatingoperatives,etc.The pairingprocedureis initiatedthroughthe willpowerofthe most essential farm operation.For many farmers, thisoperationwillprobablybe land preparation, sowing,harvesting,etc, forwhichoutrightprominence is put on the timelinessof the operation. The extreme poweressential for anytype of field procedurewillbe the power of the tractor desired. The succeedingstep-by-stepmethodwasusedinthe studyforthe predictionofthe powerrequirementofatractor: 1) Deciding the optimal size of implement, that may finish the operation in accessible time. 2) Calculate the power requirement for the implement decided to be paired.

2.2 Determination of the Size of the Implement

Any matching activity must begin by identifying the most important field operation. This will differ between regions and frequently even between farms in the same region. It can be estimated using local knowledge or historical rainfall data and is frequently decided by the amount of time between rainfall data to cover the intended area. We can determine the width of the implement required by knowing the length of time and travel speed required to complete the most crucial field activity. For the purposes of this computation, field efficiency must be taken into account. The equation can be used to determine an implement's theoretical field capacity (TFC).(Zenebe*et al.,* 2016, Kolhe 2010)

$$TFC = \frac{W \times S}{10} \text{--}(1)$$

Where; TFC is theoretical field capacity (ha/h);

W is implement width (m),

S is the operating speed (km/hr). In order to determine the required implement's effective field capacity (EFC), the whole area and working time must first be known.

$$EFC = \frac{A}{T} \quad (2)$$

Now the width of the implement can be computed based on equations 1 and 2.

$$W = \frac{A \times 1000}{S \times t \times e} \quad (3)$$

Where; EFC is effective field capacity (ha/h);

e is field efficiency (%);

Aarea to be covered (ha); and

t is available working time (hr).

2.3 Estimation of Power Requirement for Selected Implement

The travel speed and draft of a tillage tool determine the drawbar power needed to pull it. The tractor should be able to deliver this amount of power at the drawbar. There will be a noticeable increase in engine power. The draft of the implement per meter of width is shown in Table 1 for various soil types. Equation 3 is used for the calculation of the implement's width. As a result, one can estimate the overall draft for the chosen implementation. Table 1 can be used to choose an appropriate operation speed. Once the operational speed is selected, the equation 4 can be used to get the needed drawbar power (DP):

$$DP = \frac{D \times W \times S}{3.6} \quad (4)$$

Where DP is drawbar power (kW);

D is the draft of the machine (kN/m);

W is the width of the implement (m); and

S is the speed of field operation (km/h).

To specify the amount of power of our tractor, we must select a known standard that is unchanged by the numerous drawbar power-linked elements, such as soil quality, operation speed, tire size, ballasting, etc. The tractor power is typically expressed as PTO power. Calculating the necessary PTO power from known or existing drawbar power requires taking into consideration the losses caused by rolling resistance and wheel slip. By multiplying the drawbar power by a conversion factor, the tractor PTO power can be computed by using equation 5. Because overloading can result in early component failure, the tractor shouldn't operate consistently at more than 80% of its maximum power (Mclaughlin *et al.*, 2008)

$$P_{PTO} = \frac{DP}{Conversion\ factor \times 0.8} \text{---(5)}$$

Where, P_{PTO} is the PTO power (kW), and

DP is the drawbar power (kW).

2.4 Determination of Power Utilization Ratio (PUR)

The power utilization ratio is calculated by ASAE, 2000 standards as cited by (Ashok *et al.*, 2017) as shown in equation 6.

$$X = \frac{Equivalent\ PTO\ power\ required\ by\ the\ implement}{Maximum\ available\ PTO\ power\ from\ the\ tractor} \text{---(6)}$$

Where, X is the power utilization ratio

Measurement of fuel consumption

The amount of fuel needed to immediately refill the tractor's fuel tank can be measured using a graduated cylindrical container **(**Gosaye*et al.*, 2015).This measurement will show how much fuel was used throughout any activity. The fuel consumption rates were determined by Equation7. $Fuel\ consumption\ rate\left(\frac{l}{hr}\right) = \frac{Reading\ of\ cylinde, liters}{Time\ taken\ to\ cover\ land\ area, hours}$ -------------------(7)

2.5 Determination of the Size of a Tractor

For this study, the DSS provides the ideal tractor size for the activities considered. To determine the tractor size for the selected field operations, an algorithm that produced a Visual

Basic computer program was developed. Figure 1 shows the program's flowchart. The program's inputs comprised the soil type, soil condition, working speed, field efficiency, implement’s draft force, fuel consumption, fuel calorific value, field activity to be performed, and conversion factor as indicated in Figure 2. The DSS screen has three columns. The first column; an option column is shown in Figure 2. The user selects the soil type of the farm, the soil condition, the conversion factor based on the condition of the soil and the field activity to be done. The second column is the input column where the user inserts the input parameters to be calculated. Finally, the third one is the output column. Here the DSS output is displayed for the final decision to be made by the user. The program computes the required drawbar power forthe implement according to theinput data for each field activity. Using Eq. (4), the program determines the tractor's necessary drawbar power depending on the width, working speed, and draft of the implement. The software, using Eq. (5), indicated the PTO power required for a farm tractor utilizing 80 percent of its maximum engine power. Figure 3 shows a portion of the coding screen.

3.Development of theSystem (DSS)

A decision support system (DSS) was created with the intention of pairing the tractor and related equipment for various operating conditions and soil types. It was developed with Microsoft Excel as the back end and Visual Basic 6.0 as the front end. In order to finish the process and get the necessary results, a screenwas displayed. The designed displaywas extremely user-friendly, making it simple to choose the parameters and enter the necessary values whenever they were needed. There were numerous consecutive screens to complete the overall process and get preferred output. The developed screens were very intuitive and easy to select the process parameters and enter the essential values wherever requisite. The Decision support system ongoing with splash screen as shown in fig. 1 and finished with the final results requisite by the user. The part of coding screen is presented in fig. 2, if the tractor is available find out the optimum size of tractor equipment is available, find out the optimum size of tractor requirement.

Figure 1. A screen for calculation of the size of the matching tractor using DSS.

```
txtid = Val(24.93)
txtefe = Val(0.8)
txtcf = Val(0.72)
txtts = Val(6)
txtfc = Val(64.7)
txtcv = Val(12.1)
txtwi = Val(3.2)
txtrp = Val(209)
txtdpr = Val((txtid * txtwi * txtts) / (3.6))
txtdpa = Val(txtrp * 0.9 * 0.72)
txtpu = Val(txtdpr / txtdpa)
End Sub

Private Sub cmdcal2_Click()
txtid = Val(19.7)
txtefe = Val(0.8)
txtcf = Val(0.67)
txtts = Val(6)
txtfc = Val(55)
txtcv = Val(12.1)
txtwi = Val(2.8)
txtrp = Val(209)
txtdpr = Val((txtid * txtwi * txtts) / (3.6))
txtdpa = Val(txtrp * 0.9 * 0.67)
txtpu = Val(txtdpr / txtdpa)
```

Figure 2. Part of the coding screen of the Decision Support System

3.1 Database of the DSS

12 tractors with power ratings ranging from 60 to 400 hp were listed in the DSS's databases. The tractor database included options for adding new tractor model specs and modifying any parameter value that had already been input. The specification table included details on the model, the maximum PTO, no of cylinders, the cylinder volume, forward and reverse speed numbers, the speed of the PTO shaft, the specification ofwheels, theturning radius, the mass that was ballasted and unballasted, the maximum engine rpm, etc. Information on standard PTO power, the drawbar power, model, PTO power, SFC, hydraulic capacity, and braking energy were all included in the performance chart.

The database about farmshad information like types of implements and their sizesfound at WonjiShoa sugar factoryand used for this study. It included details such as the name of the implement, its model, width, maker, travel speed, field effectiveness, etc. The database about soils included details on many soil types, including sandy loam, vertisol, and heavy clay soils. For the three aforementioned soil types, the database also included data on the draft force, suggested forward speed, and estimated field efficiency of equipment like the Subsoiler, disc plow, offset or tandem disc harrow, and furrower.

1) Tractors: The DSS containeddifferent databases of available tractorsused in the wonjishoa sugar factoryof different makes and models varying from45 to 298 kWPTO power.The informationwascompiledintoadatabasecreatedusingMS Access.The information about the specifications oftractors andother implements was taken from the wonjishoa sugar factory tractor and implement department.The database on tractorshadprovisionsfor adding specifications of a new tractormodel and editing any parameter value of the entered datain the database. The specification table contained the information related to model, rated PTO power, number of cylinders, **c**ubic capacity**,** number of forward and backwardspeeds, PTO type, size of front and rear wheels, minimumradiusforturn,ballastedandballastedmass,ratedenginerpm,etc.

2) Implement andfield soils

The database on implements containedinformationabout types and sizes of the commonlyused implementsavailable in Wonjishoa sugar factoryimported from China, United Kingdom., Brazil, Spain, etc. It contained information related tothe implementname,model,width,length,height,weight,manufacturer name, typical operating speed, field efficiency,etc. The database on soils contained information about thetypeofsoils.

3) Miscellaneousdatabase

The database containedinformationon the draft, recommended speed, and field efficiency of implements suchas MBplow, one-way disc plow, tandem discharrow, duck foot cultivator, seed drill, and planter for varioussoilconditions. Thedatabasesalsocontaineddataonpowertransformationfactorsforadaptationofpowerfromdrawbar toPTOfor2WDtractors.

4) Subcomponents oftheDSS for model development

In this system, a module was developed for the selectionof a tractor-implement pairing system based on various soil andoperatingparameters.

Dimensionsoftractor

Oncechoosing a tractor, it mustalso match themost critical time delicate operation, e.g. land preparation, sowing, harvesting,etc thatlacks the highest power. Check that the power selectedwill suit all planned operations. An algorithm leading tocomputer software in Visual Basics was established to findout the optimaldimensions ofthe tractor centered on the most criticalfield operation. The flow chart of the program is shownin Fig. 3.

The decision for selection of the type of implementwas made basedon the most critical field operation(timeor power-sensitive)forthe cropping system followedinthe area. The inputstothe programincludedareatobe covered, working speed, working hours, field efficiency, etc. The DSS processedthese datawiththe help of two options i.e. pre-definedparameters(defaultvalues)anduser-definedparameters.The program calculated the working width of the implement based oninput data for the most critical fieldoperationusing Equation (3). A suitable implement having a width nearer to the calculated value was selected among the commercially availableimplementsinthemarket.Thesoftwaremaculatedtherequireddrawbarpowerofthetractor basedont h e drillandworking speed of the selected implementusing Equation(4). Finally, the PTO power requirement of a tractor usingonly 80 to 85 % of maximum engine power was advised by thesoftware based on Eq. (5). Based on calculated PTO power, the software recommended available makes and models of tractor and implement pairing f r o m theaccumulateddatabank.

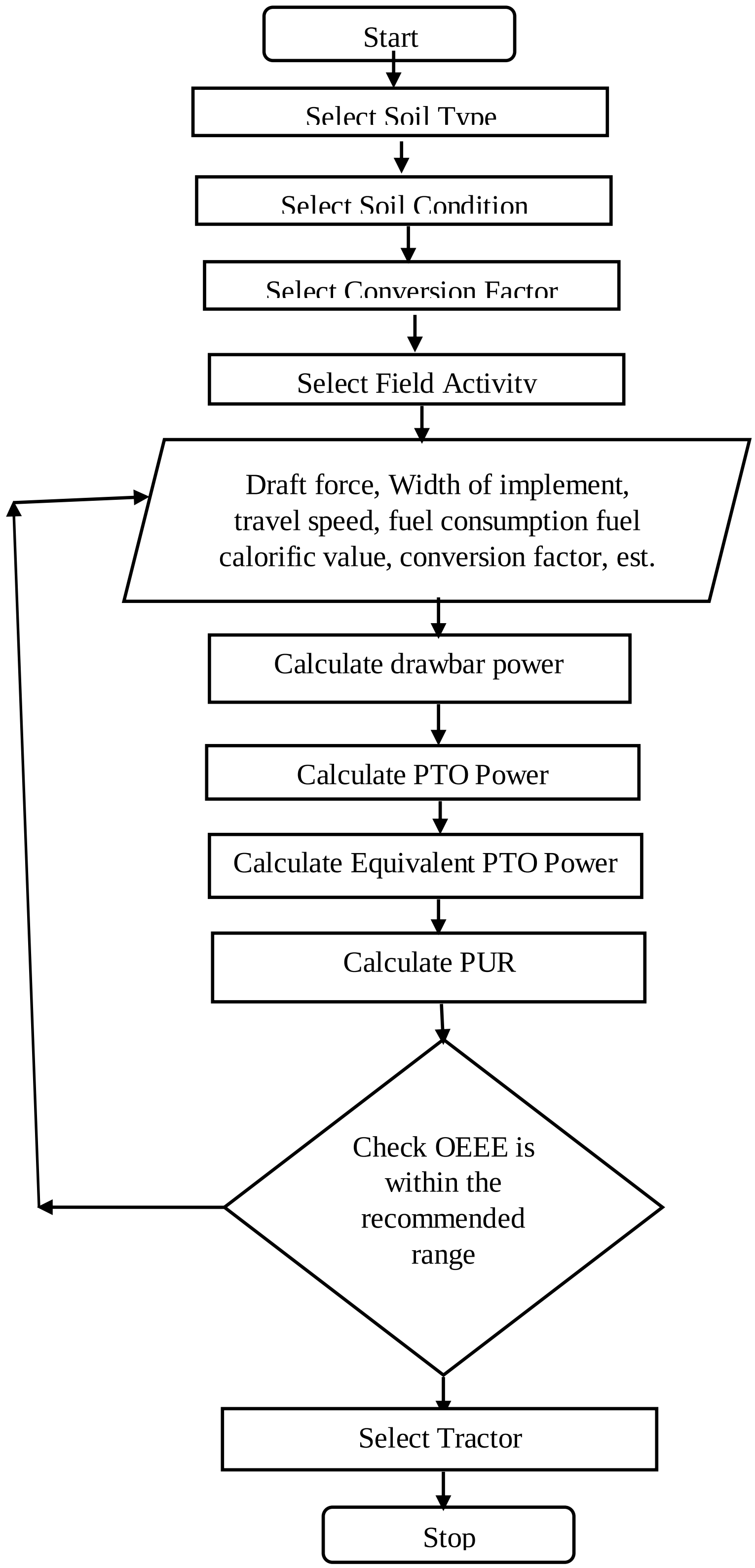

Figure 3. Flowchart for pairing the tractor-implement system for various type of soil

An important parameter, namely, Power Utilization Ratio (PUR) was also calculated by the program to quantify the extent of precision to which the tractor matches the implement. The power Utilization Ratio (PUR) was calculated by using Eq(6). Itindicates the comparison between the drawbar power available at the tractor drawbar and the one that is required for the specific field operation.

3.2 System Validation

The developed DSS was validated for implementing drawbar requirement (DBP), and power utilization ratio (PUR), using experimental data collected from the WonjiShoa sugar factory farm. The DSS's predicted output was compared with the actual field experimental data using a statistical term, relative deviation (RD), which is defined as follows(Kumar and Pandey 2009):

$$RD = \frac{1}{N}\sum_{i=1}^{N}\frac{Pi-Oi}{Pi} * 100 \quad (8)$$

Where;P is the predicted value, O is the observed value, and N is the number of observations

3.3 System Sensitivity Test

Power requirements can be changedby changing one or more variables of the model input (Draft force, Speed, Width, etc.).

4.RESULTS AND DISCUSSION

The first step in the tractor selection process is to identify the most crucial field activity to be performed in the real field like; Subsoiling, Ploughing, Harrowing, and Furrowing. Experimental results and the corresponding DSS predicted values for drawbar power and power utilization ratio (PUR) for tractor machinery selection of above stated operation for three different soil are shown in table 2. The significant reduced trend of experimental and DSS results for Drawbar power and power utilization ratio and non-significant trend of relative deviation was noted for subsoiling, plowing, harrowing and furrowing activity in heavy clay soil, vertisol, and sandy loam soil respectively. Also, very close in experimental and DSS results of (131 -132v Kw and 111-110 Kw) for sub soiling and (91.94-91.93 Kw and 86.65-87.5 Kw) for plowing, (77.40-77.46Kw and 67.10-66.5 Kw) in terms of drawbar power utilization were observed for heavy clay and sandy loamy soil. But for furrowing activity, the drawbar utilization closeness (24.7-25.2 and 25.2-24.8 Kw) was observed for verti soil and sandy loam soil. Also, there were insignificant differences between the experimental and DSS results for power utilization ratio and relative deviation for all stated soil.

For all soil types, the validity of the DSS was indicated by using a statistical term called relative deviation (RD) value for experimental and DSS drawbar requirements. From the results, it was also indicated that the field experimental result and DSS estimated value for drawbar power are very close to each other as the discrepancy between the values is less than 5 *percent*. This discrepancy may be due to some instrumental error in recording the field data as well as the degree of accuracy of the various prediction models utilized in the DSS model development. For PUR, the relative deviation (RD) was notedgreater. Also; the comparison was done between the field drawbar power of the tractor used for this experiment and the drawbar power of the appropriate tractor recommended by the DSS.

Table 2. Experimental results and the corresponding DSS predicted values for drawbar power and power utilization ratio (PUR)

Soil Type	**Subsoiling**					
	DBP(Kw)			**PUR**		
	Experimental.	DSS	RD (%)	Experimental.	DSS	RD (%)
Heavy Clay Soil	131	132.96	1.49	0.57	0.98	52
	Ploughing					
	DBP(Kw)			**PUR**		
	Experimental	DSS	RD (%)	Experimental.	DSS	RD (%)
	91.94	91.93	0.01	0.4	0.729	58.28
	Harrowing					
	DBP(Kw)			**PUR**		
	Experimental	DSS	RD (%)	Experimental.	DSS	RD (%)
	77.4	77.46	0.06	0.34	0.61	56.8
	Furrowing					
	DBP(Kw)			**PUR**		

	Experimental	DSS	RD (%)	Experimental.	DSS	RD (%)
	27.3	29.76	4.5	0.32	0.68	72
Vertisol	**Subsoiling**					
	DBP(Kw)			**PUR**		
	Experimental.	DSS	RD (%)	Experimental.	DSS	RD (%)
	121	118.6	1.98	0.52	0.76	37.5
	Ploughing					
	DBP(Kw)			**PUR**		
	Experimental	DSS	RD (%)	Experimental.	DSS	RD (%)
	86.65	87.5	0.65	0.38	0.54	34.8
	Harrowing					
	DBP(Kw)			**PUR**		
	Experimental.	DSS	RD (%)	Experimental.	DSS	RD (%)
	67.1	66.5	0.89	0.29	0.42	36.6
	Furrowing					
	DBP(Kw)			**PUR**		
	Experimental.	DSS	RD (%)	Experimental.	DSS	RD (%)
	24.7	25.2	2	0.25	0.36	36
Sandy loam soil	**Subsoiling**					
	DBP(Kw)			**PUR**		
	Experimental.	DSS	RD (%)	Experimental.	DSS	RD (%)
	111.1	110.5	0.54	0.48	0.69	36
	Ploughing					
	DBP(Kw)			**PUR**		
	Experimental.	DSS	RD (%)	Experimental.	DSS	RD (%)
	81.98	79	3.7	0.36	0.51	34.5
	Harrowing					
	DBP(Kw)			**PUR**		
	Experimental	DSS	RD (%)	Experimental.	DSS	RD (%)
	61	59.26	2.9	0.27	0.38	33.8
	Furrowing					
	DBP(Kw)			**PUR**		
	Experimental	DSS	RD (%)	Experimental.	DSS	RD (%)
	25.2	24.8	1.6	0.25	0.37	38.7

The value of PUR depends on the extent of compatibility of the tractors with their implements. For a perfectly compatible tractor and implement the value of PUR is equal to 1.

4.1 Economic Advantages of the DSS

For many organizations, selecting the right-sized tractors and implements is a crucial management choice. Correct sizing will result in less time and labor needed while maintaining effective field operations. Large tractors will result in higher than necessary fuel expenses and usage. On the other hand, if the implements are too big for the tractor, overloading will happen, resulting in poor field speeds and, as a result, reduced field capacity and work quality. In this study tractor oversize was observed for all field activities investigated and the result of differences in fuel consumption (l/ha) and lubricant cost (ha/hr) with corresponding reduced costs (USD) were presented in Table 3.

From Table 3, it was observed that the fuel consumption rate was significantly reduced by the DSS. To put it in figure it was reduced from 65 l/hr to 37.18 l/hr for heavy clay soil, 62 l/hr to 25 l/hr in vertisol, and 21 l/hr to 7 l/hr in sandy loam soil. The reduction of fuel consumption rate and corresponding lubrication oil cost per hectare indicates the significant economic advantage of the DSS. Hence by using the DSS it is possible to reduce fuel consumption cost by 1975 Birr/ha, 2627 Birr/ha, 994 Birr/ha, and 241 Birr/ha for subsoiling, ploughing, harrowing, and furrowing respectively. The cost reduction for lubrication was estimated as 10 percent of that of fuel cost

Table 3. Comparison of fuel and lubrication costs

Activity	**Fuel consumption (L/ha)**			**Saved Cost/ha in USD**	
	Experimental.	DSS	Diff.	Fuel Cost*	Lubrication cost (10% fuel cost)
Subsoiling	65	37.18	27.82	35.27	3.5
Plowing	62	25	37	47	4.7
Harrowing	21	7	14	17.7	1.8
Furrowing	7	3.6	3.4	4.3	0.43

(For the economic calculations the current rate of USD to ETB is 1:56)

The established DSS provides flexibility to pair tractor implements based on various soilconditions and operating parameters. Therefore, it may be concluded that the DSS is effective,economical, and very useful in pairing suitable tractors for the available implementation of the stated field activity.

5. CONCLUSIONS

The following conclusions were drawn from this study

1. The DSS system iselastic and user-orientedto select an appropriate implement to match the tractor based on numerous soil types, conditions, andeffectiveconstraints.
2. Decision support system assistance in the choice of a tractor or contrivance of a particular size from various brands and copies of commercially available tractors and kits at WonjiShoa Sugar factory.
3. The authentication of the Decision support system with the studies at wonjishoa sugar factory Ethiopia displays its usefulness in forecastingthe tractive performance of any effective tractor implement pairing system.
4. The agreement between results from the field experiment and the decision support system output; shows that the system accurately selects the size of the tractor (drawbar power) for the chosenimplement and the statedparameters (width of the implement, travel speed, draft force etc.).
5. The tractorsof WonjiShoa sugar factory needs higher fuel, lubrication, maintenance and spare part costs due to oversize and more horse power capacity utilization. Therefore; a significant amount of differences in fuel and lubrication consumption per hectare were observed; also thesignificant cost reduction was observed due to the appropriate pairing of Tractor-implementby using the decision support system.

Acknowledgments

The authors gratefully acknowledge Adama Science and Technology University and WonjiShoa Sugar Factory for their moral support during this research work.

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