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[F] PhD Extended Abstract Form *(Please select the Calibri 10 typeface)*

FULL PhD THESIS TITLE … "COMPARATIVE EVALUATION OF DRAFT ENERGY REQUIREMENT OF EXISTING PRIMARY TILLAGE SYSTEM IN TAMIL NADU AND DEVELOPMENT / MODIFICATION OF A TILLAGE IMPLEMENT FOR REDUCING ENERGY REQUIREMENT"

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Extended Abstract

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1. Chapter 1

INTRODUCTION

Tillage implements

In general, mould board plough and disc plough are used for primary tillage operations in India. In recent past, adoption of newly designed implements like subsoiler and five tyne cultivator are popular among the farmers in Tamil Nadu. Without any adequate knowledge on these implements, farmers are using these implements for tillage operations irrespective of the soil condition and depth of ploughing required for the crops to be grown.

The size is one of the basic criterion in selection of machinery. The width of cut and ground speed is usually adequate information to duly match the size of the implement to the farming operations. However, the contemplation of the power requirements of the equipment in order to match the available power unit is equally important in selection of implement. Because the power requirements of tillage equipment are large, the match is usually critical. The most difficult use of the power unit will be obtained only when the implement is matched correctly to the tractor's available power.

Keeping the above facts in view, an investigation titled **"Comparative evaluation of draft energy requirement of existing primary tillage system in Tamil Nadu and development / modification of a tillage implement for reducing energy requirement"** has been taken up with the specified objectives.

OBJECTIVES

- To develop an instrumentation system for measurement of draft energy requirement of various primary tillage implements.
- To measure the draft energy requirement of existing primary tillage implements with the developed instrumentation system.
- To develop / modify a tillage implement with reduced energy requirement.
- To evaluate the performance of the developed / modified tillage implement in the field and work out the cost economics.

2. Chapter 2

REVIEW OF LITERATURE

The review of previous research works related to energy requirement during tillage, concept of three-point hitch dynamometer, influence of soil properties, tool and operational parameters on the design of five tyne duck foot cultivator are presented under the following subtitles.

- ✓ Influence of soil type and condition on soil reaction

Olatunji and Davies, (2009) investigated the relationship between depth of cut, increase in height of disc plough as well as the draft using dimensional analysis on a sandy loam soil. The experiment was conducted on a site with three different levels of moisture contents at five different speeds of tractor, 0.83, 1.39, 1.94, 2.5 and 2.78 m s^{-1}. It was observed that the depth of penetration increase with an increase in draft and soil moisture content. Minimum depth of cut was measured at 4.9 per cent and maximum at 9.4 per cent moisture content. From the results, they were developed a model to determine the depth of cut of disc plough in sandy loam soil and also the draft-speed relationship. The draft increased linearly with the depth of cut as predicted from the model.

- ✓ Furrow profile meter
- ✓ Operational parameters on draft requirement
- ✓ Three point hitch dynamometer

Manohar Jesudas, (1994) developed tillage dynamometer for evaluating the performance of deep tillage tool. The behaviour of deep tillage tool under same soil conditions predicted by using existing models. The experiment was conducted five levels of share width 20, 25, 30, 40 & 50 mm and three levels of share length 100, 150 & 200 mm were fabricated with a share lift angle of 20° and tested at five levels of depth and five levels of speed. The results of the field experiments indicated that the longitudinal reaction of most shares at a depth of 35 cm and speed of 1 m s^{-1} varied between 778 kg and 1065 kg. The longitudinal reaction - depth relation was quadratic with the slope increasing from 22 kg cm^{-2} at 12.5 cm depth to 4 kg cm^{-2} at 37.5 cm depth. The vertical reaction was almost linear in the range of 15 to 25 cm depth of operation. The share width had significant influence on horizontal reaction only at depths greater than 35 cm and the horizontal reaction increased with share width. The horizontal reaction – share length relation favoured the selection of 150 mm lone share to ensure minimum draft.

- ✓ Instrumentation of data acquisition system
- ✓ Energy required in primary tillage implements

3. Chapter 3

MATERIALS AND METHODS

This chapter discusses the development of tillage dynamometer, measurement of forces on existing indigenous tillage implement *i.e.,* duck foot type plough using the tillage dynamometer and improvements made to the soil working element. The procedure adopted for calibrating tillage dynamometer is discussed. The force equations for measuring draft of duck foot type plough by tillage dynamometer was developed and presented. The methodology to study various soil and machine parameters, which are involved in studying the draft and specific draft of conventional duck foot type plough, design and development of modified/developed duck foot type plough are discussed. The procedure adopted for studying the effect of soil and machine parameters *viz.,* depth of operation, soil moisture and forward speed of operation on the draft and specific draft of existing duck foot plough by developed tillage dynamometer is presented. The study of soil and machine parameters on soil working element is explained. The design and development of duck foot type plough by reduced draft and specific draft and the effects of soil and machine parameters *viz.,* depth of operation, soil moisture and forward speed of operation on the performance of developed duck foot type plough are explained.

Design of three-point hitch dynamometer

A three-point hitch dynamometer was developed as an universal three-point dynamometer *i.e.,* it can be fitted to any tractor–implement combination. This three point hitch dynamometer is a double frame unit. The front side of this frame is attached to the tractor while the rear side of other frame is attached to the implement.

The hitch points of the rear frame are moveable for hitching with implement. The three point hitch dynamometer can be easily connected and disconnected with the tractor and implement. It uses six load cells for sensing and measuring the draft of the implement. The total weight of the three point hitch dynamometer with all accessories was 130 kg. Development of three point hitch dynamometer and views of three point hitch dynamometer. The main components of the three point hitch dynamometer are

1. Tractor side frame
2. Implement side frame

3. Load cells
4. Telemetry data acquisition system

Development of prototype duck foot type plough

A tractor drawn prototype duck foot type plough was developed based on the problem encountered from existing duck foot type plough for clay and red soil. The prototype essentially consisted of a share, shank, three point hitch and main frame. The unit was developed with modified sweep. Similar to the existing sweep with a cutting width (W) of 420 mm , length (L) of 250 mm and 20 deg sweep lift angle. The existing main frame available in the department of Agricultural machinery research centre was used for mounting the newly designed sweep.

4. Chapter 4

RESULTS AND DISCUSSION

The results of the study conducted to measure the soil reaction on conventional duck foot type tractor operated plough in order to develop energy efficient tillage tool as a substitute for the popularly used conventional tractor drawn duck foot type plough was undertaken. As it was felt that an accurate system for measurement of soil reaction on tractor drawn equipment's is necessary to conduct the study. A tractor mounted tillage tool dynamometer was developed for use in this study. This chapter presents the results of the performance of tillage tool dynamometer, soil reaction on conventional duck foot type plough in comparison with improved duck foot type plough and brings out the advantages of the modified design.

Methodology to find the soil reaction on dynamometer reading

Sample calculation to find the dynamometer recording

1. Longitudinal soil reaction, L
2. Vertical location of soil reaction below the hitch point
3. Vertical soil reaction, V, Lateral distance between hitch point and V(Positive downwards)

It is seen that the horizontal reaction is negligible because the implement is a symmetrical implement and also due to symmetric L_1 is approximately equal to L_2 and hence the soil reaction L can be assumed to be midway between the lower links. The longitudinal vertical soil reactions were combined and magnitude and direction of the resultant reaction and was found out as 408.4 respectively.

Equations RE = $\sqrt{[(L^2) + (V^2)}$

It can be assumed that the resultant reaction passed at the vertical distance of 501.86 mm from the lower link hitch point.

Cost economics

The cost of the developed prototype duck foot type plough was Rs.42000. The cost of operation was calculated and presented in Appendix C. The actual field capacity of the developed prototype was 0.024 ha h^{-1} and the cost of operation of the machine was Rs.920 ha^{-1} while the cost of operation by conventional unit (same five tyne duck foot cultivator) was Rs. 1841 ha^{-1}. The savings in cost of plough with developed unit was Rs. 921 ha^{-1} which worked out to 50 per cent comparing with conventional duck foot type cultivator .

5. Chapter 5

SUMMARY AND CONCLUSIONS

This tractor mounted tillage dynamometer was developed as a tool for conducting field research on forces on tillage tools. This equipment has been designed and developed so that it can easily be replicated. The tractor mounted tillage dynamometer was developed based on thorough review of the different tractor mounted dynamometers. This dynamometer has tractor side frame and implement side frame which are linked together through six load cells. The salient features of the dynamometer are

1. Ensures complete measurement of forces on tractor mounted implement
2. Suitable for tractors and implements with Category II hitch system
3. Weighs 130 kg
4. The total offset of the tillage instrument is 370 mm
5. The implement side hitch eye end are suitably adjustable
6. Will facilitate passage of PTO shaft through the dynamometer frame.

7. The complete frame has been checked and verified for structural integrity through FEM techniques
8. Measurement is done by precision load cells fitted with eye ends to ensure axial force measurement
9. Compact amplification cum telemetry system by using NI WSN strain gauge nodes powered by 12 V 7 A DC battery
10. Used state of art Zigbee telemetry system to receive data by data logger
11. Data logging by standard labview software

Measurement of soil reaction was made in the five bottom developed sweep plough under two soil conditions and three ranges of moisture conditions. The operating parameter viz., depth of operation and forward speed were varied and the soil reaction was measured using the tillage dynamometer. The study showed that the lateral side forces and vertical forces were negligible and predominant force only the longitudinal soil reaction L and these forces are analysed and since no other component of soil forces is defined, L is equal to Px that is draft. The draft is major factor of importance and it was found that the draft linearly increased with depth when the depth is increased from 150 to 250 mm also in the range of speed test 4.7 km h^{-1} the draft – Speed relation almost linear as maximum draft was obtained in black cotton soil with the moisture content of 10 – 13 per cent. When the speed of operation 7 km h^{-1}, depth of operation 250 mm and draft was found to be 840.40kg. The maximum draft force is similar to the observation of 478.20 kg, moisture content of 10 – 13 per cent, 200 mm depth of operation and speed 5 km h^{-1}. This showed that the draft of the tillage in black cotton soil 760.74 kg more than the 793.91 kg red soil. Since for efficient tillage the draft per unit cross section of the furrow as to be minimum of the specific draft were compared for different soil and soil conditions of the conventional plough. It was found that the specific draft was minimum at 111.53 kPa occurring at 10 – 13 per cent moisture content, operating speed of 5 km h^{-1}, depth 200 mm. similarly the minimum specific draft of red soil observed at 14 - 16 per cent moisture content, operating speed of 7 km h^{-1}, depth 250 mm. Specific draft vs depth was found to be linearly decreasing relation and specific draft decreases from 105.55 to 132.95 kPa. When the depth increased from 150 to 200 mm in black soil at a moisture content 10 to 13 per cent, similarly the specific draft decreased from 89.2 to 104.28 kPa when the depth increased from 150 to 250 mm in red soil, when the moisture content 10 – 13 per cent and speed 3 km h^{-1}. The savings in cost of ploughing with developed unit was Rs. 921 ha^{-1} which worked out to 50 per cent comparing with conventional duck foot type cultivator .

Final remarks concerning the competition benchmarks and strength points

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Primary tillage

Three point hitch dynamometer

Five tyne duck foot plough

LAB View

Data logging

Speed of operation

Depth of operation

Soil moisture content