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RESEARCH ARTICLE

Development of indigenous plough for ridging and inter cultural operations for sugarcane crop

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ABSTRACT : Sugarcane crop has been pride of Maharashtra state and plays a vital role in agricultural economy of the state. Maharashtra state had established enviable position in the Indian sugar industry by contributing 35 per cent of total sugar production (8.5 Million Tonnes of sugar). In spite of this in sugarcane crop system traditional methods of weeding and earthing up is labour as well as time consuming and cannot be done by tractor drawn implements because of restriction for their movement in sugarcane row as well as less land holding capacity of Indian formers. So that, the bullock drawn ridger and inter cultivators have got popularity in the major part of the country. Also all these operations in sugarcane crop are carried out using bullock drawn implements. Keeping above points in view the study was undertaken entitled, with view to fabricate and develop indigenous plough for ridging and inter-cultural operations for sugarcane crops. For the study the popular Kirloskar iron plough was selected as it is widely used in the region. This selected plough was developed such that it has furrowing and weeding tools with view to number of operations at a single pass of implement. It can also used for ridging, earthing up and weeding operation.The testing of developed indigenous plough was carried out in Kagal Tahsil of Kolhapur district for sugarcane crop by following RNAM standard test codes. The power required for ridging, earthing up and weeding operations was 0.91 hp, 1.26 hp and 1.38 hp, respectively. The effective field capacity was obtained about 0.18 ha/hr. 0.21 ha/hr. and 0.24 ha/hr. for ridging, earthing- up and weeding operations, respectively. The field efficiency of implement was obtained about 51.55 per cent, 56.58 per cent and 51.45 per cent for ridging, earthing up and weeding operations, respectively. The cost of operation of implement was obtained as 315.28 Rs./ha, 289.34 Rs./ha and 304.10 Rs./ha for ridging, earthing up and weeding operations, respectively. In this way newly developed indigenous plough had given better results especially for doing earthing up operation. Hence, the performance of newly developed indigenous plough was found satisfactory.

KEY WORDS : Animal drawn, Mould board plough, Animal drawn cultivators, Animal drawn weeders, Sugarcane

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INTRODUCTION

Sugarcane (*Saccharam officinarum*) is a most important cash crop mostly grown in tropical and subtropical countries of the world. India is one of the most important sugarcane growing countries in the world. Sugarcane crop has been pride of Maharashtra state and plays a vital role in agricultural economy of the state. Maharashtra ranks 1st in production and productivity and ranks 2nd for area under cultivation in India.

Sugarcane requires a very through and clean preparation of the land. As the sugarcane crop has long life period, intercultural and ridging operations are necessary for better production of sugarcane crop. The ridging is one of the improved soil and water conservation practices for sugarcane crop. It controls the runoff, prevent erosion, facilitates drainage and increases water application efficiency, conserves soil moisture and there by increases crop production.

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Intercultural operations include weeding as well as earthing up. Weeding is another most important intercultural operation this is due to that, weeds are the competitors to the sugarcane crop and may reduce yield by 30 per cent to 50 per cent (By Jai Research Foundation, Gujarat). After the germination, depending upon the field conditions and frequency of irrigation, two or more weeding operations are required during the first three months of planting. By incorporating the effective methods of weeding yield of crop increases. As well as cost of production reduces with reduction in fertilizer cost and irrigation. The earthing up is another important intercultural operation in sugarcane crop. This operation should be done when sugarcane root system has been sufficiently developed. This operation is carried out in order to support the stalks against strong winds and also destroys weeds presents in rows.

In spite of this in sugarcane crop system traditional methods of weeding and earthing up are labour as well as time consuming. Also these ridging and intercultural operations are cannot be done by tractor drawn implements because of restriction for their movement in sugarcane row as well as less land holding capacity of Indian farmers. So that, bullock drawn ridger and inter cultivators have got popularity in the major part of the country.

So, development of the selected plough will be done such that the furrow wings will be attached to the plough, which will facilitates the ridging and furrowing and earthing up operation. Also development will include attachment of cutting blades which will surely help in interculture or weed removal. Such the development of the plough will definitely reduce the drudgery of humans also it will take in to account the economic constraint the farmers of the regions. And more importantly it will provide multipurpose use *i.e*. it can be used for ridging and furrowing, earthing up and weeding.

Keeping above points in view the study was undertaken on Development of Indigenous plough for ridging and intercultural operations in sugarcane crop with following objectives:

–To fabricate of developed indigenous plough for ridging and inter cultural operations for sugarcane crops and to test of developed indigenous plough for ridging and inter cultural operations for sugarcane crops.

EXPERIMENTAL PROCEDURE

The existing plough was attached with furrow wings for furrowing and earthing up and blades were mounted on these wings as intercultural attachment. Both these attachment were done to have number of operations in sugarcane crop production system in single pass of implement. The various components of existing plough and developments *i.e.* components attachments of developed plough are discussed as follows.

Constructional features of existing indigenous plough :

In Maharashtra a traditional iron plough is widely used, which is made up of Kirloskar Company Ltd. It consists of different components *viz.*, share is the main components which penetrate in to soil and makes horizontal cut below the surface. It is made up of cast iron such that of triangular in shape with 35 cm in length, 15 cm in width and 2.5cm thick. Another important component is landside which is flat plate like structure that bears against and transmits the rear side lateral thrust of plough bottom to furrow wall. The selected plough has triangular shape with 35 cm of length and 15 cm width.

Shoe is the next component of the ploughs, which penetrates in to the soil and breaks the soil. It helps in stabilizing and balancing the plough during operation. Selected plough has triangular shaped shoe with 35 cm length, 15 cm width. Another most important component of the plough is beam. Beam is that part which transmits the power of the bullocks to the plough. Handle is another component of the plough, which is used for stabilizing and handling the plough during operation. It is made up of mild steel with 126 cm height. The grip of the handle is made up of mild steel with 12 cm length and 6 cm diameter.

Constructional features of developed plough :

The selected plough was taken up for different development, the different attachment and components can be described as below:

Furrow wing :

Two furrow wings were attached with an arrangement of adjustable furrow width it is made of mild steel which turns the furrow slices into V shaped ridges. The different adjustments are provided for the various widths of furrow ridges with the help of hinges and locking arrangement. This furrow wing is designed in such way that, it forms V- shaped ridges with 45 cm depth and varying width. Cutting blades are mounted on the outer edge of furrow wings for the purpose of cutting of weed during operation. For adjustment of the working width of operation mild steel angle plates are provided at its back side. This has sets of holes for adjusting different widths varying from 45 cm to 120 cm.

Cutting blades :

The cutting blades of mild steel are mounted on the outer edge of furrow wings for cutting of weed on ridges. The blades were joined to the plough such that, it will cut down the weeds on the ridges horizontally during operation by slicing action. These blades are joined to the plough by providing the holes on both wings and blades.

Adjustable plate :

The adjustable plate is provided on back side of the

furrow wing for adjusting working width of the plough. It consists of pair of mild steel angle plate which has sets of holes to obtained required working width. The adjustable plate is 37.5 cm in length having 5 holes at spacing about 7.5 cm.

Field testing of developed indigenous plough for ridging and intercultural operations in sugarcane crop :

Testing of developed indigenous plough was carried out using RNAM standard test codes. Various parameters measured and calculated are as follows. The test plots were selected considering the RNAM standard test code. The following field condition of plot were checked and reported during the field test and before field test.

– Size of the plot.
– Type of soil.
– Last crop grown.
– Date of last crop harvested.
– Date and details of preceding tillage treatments.
– Topography of land.
– Soil moisture
– Bulk density

Actual field test :

During actual field test following parameters were judged.

Measurement of draft :

During the test dynamometer is used to measure the draft. The draft is nothing but the horizontal component of pull parallel to the line of motion. If the dynamometer is not horizontal then, line of plough makes with horizontal is measured to calculate draft.

Draft requirement is given by,

$D = P \cos \theta$

where,

D = Draft in kgf,
P = Pull in kgf,
θ = Angle between line of pull and horizontal

Measurement of power required for operation :

For determination of power required for operation, speed of operation is required to be measured. Foe measurement of speed, 30 m length in the field was selected. Then speed was calculated by dividing time required to travel this marked distance. Then speed is determined by taking average of five readings.

Then power required for operation is calculated by formula:

$$\textbf{Power in HP} = \frac{\textbf{draft in kgf. x speed in m/sec}}{\textbf{75}}$$

Effective field capacity :

Effective field capacity was determined by operating the implement for whole plot. Plot was ploughed by strip ploughing method. During the test, productive time *i.e.* time required for actual operation was measured for ploughing whole plot. Similarly time loss due to number of reasons was measured for whole plot.

Then effective field capacity is calculated by dividing total time (productive time + lossed time) to the area of plot. Then the effective field capacity was determined by, the formula:

$$\textbf{EFC} = \frac{\textbf{A}}{(\textbf{T}_p + \textbf{T}_i)}$$

where,

A = Area of test field m^2
Tp = Effective time in hr.
Ti = Lossed time in hr.

Theoretical field capacity :

For determination theoretical field capacity width of plough was measured during actual field test. Then width is calculated by taking average of five readings. Then theoretical field capacity is calculated by using following formula:

$$\textbf{Theoretical field capacity (ha/hr)} = \frac{\textbf{width (cm) x speed (m/sec) x 36}}{\textbf{10000}}$$

Field efficiency :

The field efficiency is ratio of effective field capacity to theoretical field capacity. It is calculated by taking ratio of effective field capacity and theoretical field capacity. The formula for determination of field efficiency is as below:

$$\textbf{Field efficiency} = \frac{\textbf{Effective field capacity x 100}}{\textbf{Theoretical field capacity}}$$

Cost economics :

In this section the fixed cost, variable cost and operating cost for developed indigenous plough is given. The operating cost is addition of fixed cost and variable cost.

Fixed cost :

– Cost of machine
– Depreciation (Rs./Hr)
  = (C-S) / (L x H)
– Interest (Rs. /Hr)
  = ((C+S) / 2) x I / H
– Insurance and taxes (Rs. /Hr.) = 2 % of initial cost
– Housing (Rs./Hr) = 1.5 % of initial cost
  Total fixed cost = 2 + 3 + 4 + 5

Variable cost :

– Operators cost
  = Wage of operator / Working hours
– Operators cost of pair of bullocks

= Wage of pair of bullocks / Working hours

– Repair and maintenance (Rs /Hr) = 6 % of initial cost

Total variable cost = 1 + 2 + 3

Operating cost :

$$= \textbf{Fixed cost} + \textbf{Variable cost}$$

where,

C = Initial cost or cost of machine, Rs.

H= Annual use of machine, hr

I = Interest rate, %

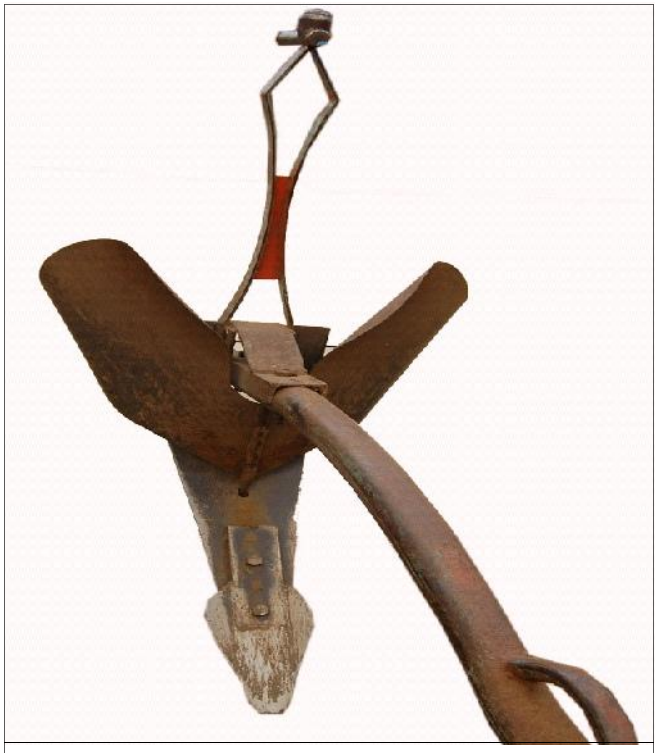

Fig. A : Developed indigenous plough with its component

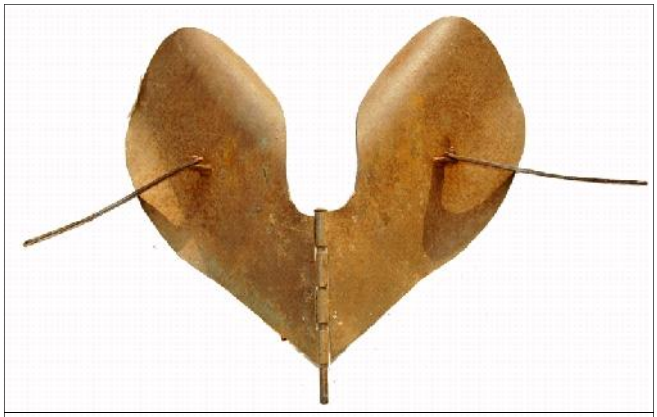

Fig. B : Furrow wings of developed indigenous plough

L = Total life of machine, yr

S = Salvage value, Rs.

EXPERIMENTAL FINDINGS AND ANALYSIS

The developed implement was tested using RNAM standard test code for following operations and different parameters on the field are as follows :

For ridging operation :

The draft required for ridging operation was obtained as 67 kgf, 67.05 kgf and 67.03 kgf for Test 1, Test 2 and Test 3, respectively. The average value of draft for ridging operation was 67.20 kgf. Power required for the operation was found to be 1.16 hp, 0.97 hp and 0.88 hp for Test 1, Test 2 and Test 3, respectively. The average value for power required for ridging operation was 1.04 hp.

The effective field capacity was obtained as 0.19ha/hr, 0.18ha/hr and 0.17ha/hr for Test 1, Test 2 and Test 3 respectively. The average value of effective capacity for ridging was 0.18 ha/hr. Field efficiency for the operation was found to be 47.98 per cent, 53.79 per cent and 54.37 per cent for Test 1, Test 2 and Test 3, respectively. The average field efficiency was 51.55 per cent for the operation.

For earthingh up operation :

The draft required for earthing up operation was obtained as 97.5 kgf, 97.55 kgf and 97.60 kgf for Test 1, Test 2 and Test 3, respectively. The average value of draft for earthing up operation was 97.55 kgf. Power required for the operation was found to be 1.43 hp, 1.17 hp and 1.56 hp for Test 1, Test 2 and Test 3, respectively. The average value for power required for earthing up operation was 1.39 hp.

The effective field capacity was obtained as 0.21 ha/hr, 0.21 ha/hr and 0.22 ha/hr for Test 1,Test 2 and Test 3, respectively. The average value of effective capacity for earthing up was 0.21 ha/hr. Field efficiency for the operation was found to be 50.26 per cent, 62.36 per cent and 50.03 per cent for Test 1, Test 2 and Test 3, respectively. The average field efficiency was 56.58 per cent for the operation.

For weeding operation :

The draft required for weeding operation was obtained as 97.5 kgf, 97.55 kgf and 97.60 kgf for Test 1, Test 2 and Test 3, respectively. The average value of draft for weeding operation was 97.55 kgf. Power required for the operation was found to be 1.48 hp, 1.56 hp and 1.52 hp for Test 1, Test 2 and Test 3, respectively. The average value for power required for weeding operation was 1.52 hp.

The effective field capacity was obtained as 0.23 ha/hr, 0.23 ha/hr and 0.23 ha/hr for Test 1, Test 2 and Test 3, respectively. The average value of effective capacity for

Table 1: Ridging operation of developed indigenous plough

Sr. No.	Particular	Plot 1	Plot 2	Plot 3
1.	Plot size (m ×m)	25×25	25×25	25×25
2.	Topography	Well leveled	Well leveled	Well leveled
3.	Soil description	Red soil	Red soil	Red soil
4.	Previous crops	Sugarcane	Sugarcane	Sugarcane
5.	Operating pattern	Strip ploughing	Strip ploughing	Strip ploughing
6.	Working depth (cm)	38	40	38.5
7.	Working width (cm)	87	87.5	89.5
8.	Draft (kgf)	61.08	61.5	61.08
9.	Speed (m/s)	1.30	1.09	0.98
10.	Power (hp)	1.16	0.970	0.875
11.	Time taken to complete operation (min)	18.22	20.30	21.84
12.	Theoretical field capacity (ha/hr).	0.41	0.34	0.36
13.	Effective field capacity (ha/hr.)	0.19	0.18	0.17
14.	Field efficiency (%)	47.98	53.79	54.37

Table 2 : Earthing up operation of developed indigenous plough

Sr. No.	Particular	Plot 1	Plot 2	Plot 3
1.	Plot size (m^2)	70×26	70×26	70×26
2.	Topography	Well leveled	Well leveled	Well leveled
3.	Soil description	Black cotton	Black cotton	Black cotton
4.	Operating pattern	Strip ploughing	Strip ploughing	Strip ploughing
5.	Working depth (cm)	41.20	38.10	40.00
6.	Working width (cm)	104	103.5	102.5
7.	Draft (kgf)	89.90	89.90	89.90
8.	Speed m/s)	1.10	0.90	1.10
9.	Power (hp)	1.43	1.17	1.56
10.	Time taken to complete operation (min)	53.20	52.30	51.50
11.	Theoretical field capacity	0.41	0.33	0.46
12.	Effective field capacity	0.21	0.21	0.22
13.	Field efficiency (%)	50.26	62.36	50.03

Table 3: Weeding operation of developed indigenous plough

Sr. No.	Particular	Plot 1	Plot 2	Plot 3
1.	Plot size (m^2)	70×26	70×26	70×26
2.	Topography	Well leveled	Well leveled	Well leveled
3.	Soil description	Black cotton soil	Black cotton soil	Black cotton soil
4.	Previous cultivation	Earthing-up	Earthing-up	Earthing-up
5.	Previous crops	Rice	Rice	Rice
6.	Operating pattern	Strip ploughing	Strip ploughing	Strip ploughing
7.	Working depth cm)	41.20	38.10	40.00
8.	Working width (cm)	106.10	106.80	107.00
9.	Draft (kgf)	89.90	89.90	89.90
10.	Speed (m/s)	1.15	1.19	1.17
11.	Power (hp)	1.26	1.26	1.26
12.	Time taken to complete operation (min)	47.20	48.30	46.56
13.	Theoretical field capacity	0.44	0.46	0.45
14.	Effective field capacity	0.23	0.23	0.23
15.	Field efficiency (%)	55.56	56.61	57.48
16.	Weed before test (No.)	7	6	8
17.	Weed after test (No.)	2	1	3
18.	Weeding efficiency (%)	71.42	83.33	62.50

weeding was 0.23 ha/hr. Field efficiency for the operation was found to be 50.08 per cent, 49.22 per cent and 51.98 per cent for Test 1, Test 2 and Test 3, respectively. The average field efficiency was 51.45 per cent for the operation.

Conclusion :

For the study the Kirloskar's iron plough was selected as it is widely used in the region. This selected plough was developed such that it has furrow wings and weeding tools with view to number of operations at a single pass of implement. It can also be used for ridging, earthing up and weeding operation.Developed indigenous plough was tested for its working and performance by using RNAM standard test code.

The following conclusions were drawn from the observations recorded during laboratory and field testing of implement.

- The average working speed was found to be 1.123 m/s, 1.066 m/s and 1.169 m/s for ridging, earthing up and weeding operations, respectively.
- The power required for ridging, earthing up and weeding operations was 0.91 hp, 1.264 hp and 1.385 hp, respectively.
- The theoretical field capacity of implement was found to be 0.36 ha/hr, 0.39 ha/hr. and 0.45 ha/hr. for ridging, earthing up and weeding operations, respectively.
- The effective field capacity was found to be 0.18 ha/hr. 0.22 ha/hr. and 0.22 ha/hr. for ridging, earthing up and weeding operations, respectively.
- The field efficiency of implement was obtained as 51.55 per cent, 56.58 per cent and 51.45 per cent for ridging, earthing up and weeding operations, respectively.
- The operating cost of implement was obtained as 48.64 Rs/hr. for ridging, earthing up and weeding operations, respectively.
- The total cost of operation of implement was obtained as 315.28 Rs/ha, 289.34 Rs/ha and 304.10Rs/ha for ridging, earthing up and weeding operations, respectively.
- Hence, the performance of newly developed indigenous plough was found satisfactory and had given best result for earthing up operation.

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