Techno-Economic Feasibility of Small Tractor Operated Broad Bed Furrow Maker

Authors Name:- K.H.Telang (M-Tech)
Dept.of Farm power and machinery
Dr.Panjabrao Deshmukh Krishi Vidhyapeeth.
Akola, India.

Authors Name:- Dr.V.P.Khambalkar
.(Asst.Prof.).Dept. of Unconventional Energy Sources and Electrical Engineering.
Dr.Panjabrao Deshmukh Krishi Vidhyapeeth.
Akola, India

Dr.S.H.Thakare, Dr.S.K.Thakare, Dr.(Ms).M.M.Deshmukh.
(Prof & HOD.): Dept. of Farm power and machinery.
Dr.Panjabrao Deshmukh Krishi Vidhyapeeth.
Akola, India

Abstract:- A Small tractor operated BBF maker was developed and evaluated for its performance in the Department of Farm power and machinery, Dr.PDKV, Akola. Techno-economic feasibility of small Tractor operated broad bed furrow maker was carried out during the study. Implement was tested in laboratory and in the field .The main components of the implement were main frame, hitch assembly, forming board, adjustment lever, cutting blade, hitch pair. The working width was 120 cm depth of operation was 25 cm. The average draft requirement of the implement was 164.4 kgf for implement at an average speed of 2.22 km/h for the range of 18.5 hp tractor. The average effective field capacity, theoretical field capacity and field efficiency of implement was found to be 0.30 ha/h, 0.40 ha/h and 76.97 per cent respectively. The average collection efficiency was found to be 81.47 per cent and wear per cent was found to be 0.041%/h. The operational cost for broad bed making was Rs. 258.94/h and Rs 914.30/ha. The overall performance of the small tractor operated broad bed maker during the operation of was found to be satisfactory.

Keywords:- *Field Capacity, Field Efficiency, Fuel Consumption.*

I. INTRODUCTION

Now a day's bed making is done by traditational methods such as manually collecting after ploughing or harrowing operation. The operation is done with the help of women, child labor etc.Such type of operation required more labor and time to consume and increase the cost of operation. Development and performance evaluation of small tractor operated broad bed furrow maker can fulfill the mechanization gap between the harrowing and sowing operation at the faster rate. Tractor operated broad bed furrow maker has given the good result. This implies that there is an urgent need to introduce this type of implement. Development of small tractor broad bed furrow maker is the need of our today's farming to reduce the drudgery in the operation with saving time and labor, to do work effectively and covering more area with minimum time Techno-economic feasibility of small tractor operated broad bed furrow maker could fill the gap between the ploughing, harrowing and sowing operation at the faster rate.

II. METHODOLOGY

A. *Specification of Machine*

- Size of implement was 1200x 600 x50 mm.
- Size of blades was 75mm x 10 mm.
- The distance between two forming board is kept 90 cm and 55 cm from the front and rear side

B. *Experimental technique*

The field experiment was conducted. To evaluation of techno-economic performance of small tractor operated broad bed furrow maker, the following parameters have been considered.

- *Soil parameters*
  - Soil Moisture content
  - Soil Bulk density

- *Machine operational parameters*
  - Speed of operation
  - Draft requirement
  - Theoretical field capacity
  - Effective field capacity
  - Field efficiency
  - Fuel consumption
  - Tractor wheel slip
  - Collection efficiency

The performance of the machine was evaluated by taking laboratory test and field tests.

➢ *Soil Parameters*

- *Moisture content of soil.*

The soil moisture content has influence on draft, work ability, power transmission of machine during operation and wheel slippage. Hence moisture content of soils major soil parameter which influences the design.

The moisture content of soil was calculated by formula.

$$\text{Moisture content (db)} = \frac{\text{Wt. of wet soil sample} - \text{Wt. of oven dry soil sample}}{\text{Wt. of wet soil sample}} X\,100$$

- *Bulk density of soil.*

Measure of compaction of soil condition is Bulk density which influences the machine components. Bulk density of the soil for the sowing in black cotton soil was considered in the range from 1.51 to 1.63 Mg/m^3. It was calculated by the formula.

$$\text{Bulk density}(g/cm^3) = \frac{\text{Mass of soil sample}}{\text{Volume of core cutter}}$$

➢ *Machine operational parameters.*

- *Speed of operation*

The forward speed of operation was calculated by observing the distance traveled with time taken and calculated by following formula (Mehta *et al.*, 2005) [6].

$$S = \frac{L}{t}$$

Where,
S = forward speed of machine, m/s
L = distance travelled, m
t = time taken, s

- *Draft of the implement*

Draft measurement was done with the help of digital dynamometer with load cell. Requirement of implement were calculated by following formula (Mehta *et al.*, 2005) [6].

Draft of Implement = With load draft – Without load draft

- *Theoretical Field Capacity*

Working width and travelling speed was taken in to consideration for calculating the theoretical field capacity which is always greater than the actual field capacity.

$$T.F.C. = \frac{S \times W}{10}$$

Where,
T.F.C. = theoretical field capacity (ha/h)
W = theoretical width of Implement (m)
S = speed of operation (km/h)

- *Effective Field Capacity*

For calculating effective field capacity, the time consumed for actual work and lost for other activities such as turning and cleaning blades when clogged with soil clods took in to consideration.

Using the below formula Effective actual field capacity was calculated.

$$E.F.C. = \frac{A}{T_p + T_1}$$

Where,

E.F.C. = effective field capacity, ha/h
A = area, ha
T_p= productive time, h
T_1= non-productive time, h (Time loss for turning and cleaning blades)

- *Field Efficiency*

Field efficiency was calculated by taking ratio of effective field capacity to theoretical field capacity. It is always expressed in percentage. It was calculated by following formula.

$$\text{Field efficiency (\%)} = \frac{\text{E.F.C.}}{\text{T.F.C.}} \times 100$$

Where,
E.F.C. = effective field capacity, ha/h
T.F.C. = theoretical field capacity, ha/h

- *Fuel consumption*

The tractor was placed on the plain leveled ground surface then, the fuel tank of tractor was filled up to top of the tank before operation. After the operation performed by the tractor it is again placed on the same plain leveled ground surface and by using the measuring cylinder the required amount of fuel is poured in the tractor fuel tank to make up the original level. The quantity of fuel required to make up the original level as before the operation was the actual field consumption.

- *Tractor wheel slip*

The tractor driven wheel normally slips in all field operations. The two factors which influence the tractor wheel slip are depth of operation and moisture content of soil. The determination of tractor wheel slip in per cent is useful to estimate the loss of power from ground during actual field operation approximately. The slip will affect the speed of operation and there by the effective field capacity of the implement. The tractor wheel slip was determined in percentage by using following formula. Observations and results are presented in Table
Wheel slip, % = N_1-N_2 / N_2

Where,
N_1 = No. of revolutions of tractor wheel without load.
N_2 = No. of revolutions of tractor wheel with load

C. Cost of operation per hour of small tractor operated broad bed furrow maker

The total cost of operation of small tractor operated broad bed furrow maker per hour is the addition of cost of operation of tractor and cost of operation of implement per hour. Cost estimation depends upon fixed costs and operating costs. Cost of operation of the tractor and implement including fixed and variable costs per hour is calculated by using the below presented formulae.

- *Fixed cost includes*
- Depreciation
- Interest
- Housing
- Insurance
- Taxes

- *Variable cost*
- Fuel cost
- Lubricant cost
- Repair and maintenance cost
- Wages.

- *Total cost (A + B)*

- *Fixed cost per hour*

It was calculated by taking total of following costs.

- *Depreciation*

It is loss of value of tractor and implement with passing of time and was calculated by following formula.

$$D = \frac{P - S}{L X L}$$

Where,
D = Depreciation per hour
P = Purchase price or capital investment
S = Salvage value which is 10% of purchase price
L = Total life of tractor and implement in years
h = No. of working hours of tractor and implement per year

- *Interest*

It was calculated on the average investment of the tractor and implement by taking into consideration the value of the tractor and implement in first and last year and was calculated by following formula,

$$I = \frac{P+S}{S} X \frac{R}{100 x h}$$

Where,
I = Interest to be paid per hour
R= Rate of interest per year (taken as 12 per cent)

- *Housing*

It was calculated on the basis of the prevailing rates of the market but roughly taken as 1 per cent of the initial cost of the tractor and implement per year.

$$I = \frac{P}{h} x \frac{1}{100}$$

Where,
H = Housing cost per hour (taken 1 per cent of purchase price)

- *Insurance*

For a tractor, it is taken as 1 per cent of purchase price and for the implement; insurance charges were taken as Nil.

- *Taxes*

For a tractor, it is taken as 1 per cent of purchase price and for the implement, taxes were taken as Nil.

- *Variable cost*

It includes a total of following costs.

- *Fuel cost*

It includes actual cost paid for fuel during operation of the tractor. To implement fuel charges were taken as Nil.

- *Lubricants cost*

For the tractor, it is taken as 10 per cent of fuel cost and for the implement, it was taken as Nil.

- *Repair and maintenance cost per hour*

Generally, it varies between 5 to 10 per cent of the initial cost per year. Here, it was considered 8 per cent of the initial cost and calculated as.

$$R\&M = \frac{8 x P}{100 x h}$$

- *Wages of operator per hour*

As one skilled labour was required for operating small tractor operated broad bed furrow maker, its charge per hour was calculated by considering current labour charges.

D. Determination of cost of operation per hectare of small tractor operated broad bed furrow maker

The Total cost of operation of developed implement in Rs/ha was calculated by using following formula.

$$Cost\ of\ operation\ \left(\frac{Rs}{ha}\right) = \frac{\text{Cost of operation of implement (Rs/h)}}{\text{Effective field capacity of implement}(\frac{\text{ha}}{\text{h}})}$$

III. RESULT AND DISCUSSION.

The field experiment was out carried at dairy field and Agronomy field of Dr. PDKV Akola, for maize and sorghum crop stubbles. A field of 1.2 ha area was selected for performance of machine.

A. Experimental Results.

SN	Particulars	Trial I	Trial II	Trial III	Avg. Result
1	Area covered, m^2	4000			
2	Actual operating time, min	67.63	71.01	69.25	69.29
3	Time loss in turning, min	20.50	17.03	19.62	19.05
4	Depth of operation, cm	24	25	26	25
5	Forward speed, km/h	2.25	2.15	2.27	2.22
6	Effective field capacity, ha/h	0.30	0.29	0.29	0.30
7	Theoretical field capacity, ha/h	0.40	0.38	0.40	0.40
8	Field efficiency, %	75.74	79.08	76.08	76.97
9	Draft requirement, kgf	158.30	175.50	159.50	164.40
10	Fuel consumption, l/h	3.21	3.25	3.18	3.21
11	Wheel slippage, %	9.29	6.68	8.83	8.26

Soil moisture content was determined during field test by gravimetric method. The average moisture content of the soil at the time of bed making was found at 4.27 percent.

B. Bulk density of soil

The bulk density of soil was calculated by considering the weight of core cutter, the mass of core cutter + wet soil, the mass of core cutter + dry soil and volume of core cutter. The bulk density of soil was 1.101 gm/cm^3.

C. Speed of Operation

The speed was calculated by the time required for the machine to travel the distance of 20 m between two poles. Averages of such readings were taken to calculate the traveling speed of operation. The average forward speed of tractor was found 2.21 km/h during the test. Which was close to the findings of Amonov *et al.* (2006) who checked the accuracy of different types of cultivator for cotton crops and the speed was in the range of 1.79 km/h to 5.29 km/h.

D. Draft requirement

To measure the draft required for the 18.5 hp tractor, total 10 observations were taken with load and without load conditions. The draft of implement was measured by using hydraulic pull type dynamometer. The draft required was found 164.4kgf at an average speed of 2.22 km/h.

a) Without load condition b) With load condition

Fig 1:- Draft measurement

E. Theoretical Field Capacity

The theoretical field capacity of machine for trial was found to be 0.40 ha/h. Theoretical field capacity depends upon the speed of operation and theoretical width covered by the implement

F. Effective Field Capacity

The effective field capacity was calculated by considering the productive as well as the non-productive time required during the field operation of the implement. The effective field capacity of the machine for trial was found to be 0.30 ha/h respectively.

Fig 2: Bed formation during field trial

G. Field efficiency

The average field efficiency of the machine for maize and sorghum broad bed was found to be 76.97 per cent respectively. The field efficiency was decreased with increase in speed of machine as shown in fig. 1 and fig. 3

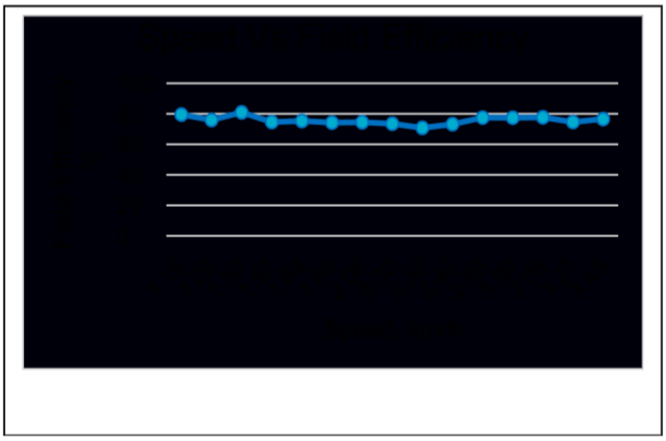

Fig 3: Speed versus field efficiency for maize furrow.

H. Fuel consumption

The average fuel consumption of machine for maize and sorghum broad bed was found to be 3.21 lit/ha.

I. Tractor wheel slip

The average wheel slip of the tractor for operation of maize stubble collection and sorghum broad bed was found to be 8.26 per cent.

J. Cost of operation per hectare of small tractor operated Broad bed furrow maker.

The cost of operation per hectare of small tractor operated broad bed furrow maker depends upon the cost of operation per hour and field capacity in ha/h of the implement. The cost of operation per hectare of developed implement was estimated to be Rs. 914.30 per ha.

IV. CONCLUSIONS

The performance of small tractor operated broad bed furrow maker was evaluated in terms of field efficiency, fixed cost and operating cost. The experiments were conducted in two different crops with different forward speed at different moisture content. The field observations were analyzed which give the performance small tractor operated broad bed furrow maker. The type of soil was heavy clay soil where experiments were conducted. The effective field capacity and theoretical field capacity of small tractor operated broad bed furrow maker was found to be 0.30 ha/day and 0.40 ha/day respectively. The average draft requirement of the implement was 164.4 kgf for the implement at an average speed of 2.22 km/h for the range of 18.5 hp tractor. The maximum field efficiency was found to be 76.97 per cent. The saving in cost and time were 85 per cent and 75 per cent, respectively as compare to traditional method of bed making. The overall performance of the small tractor operated folding type stubble collector during the operation was found to be satisfactory.

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