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Techno-economic performance evaluation of small tractor operated folding type stubble collector

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Abstract
A small tractor operated folding type stubble collector was developed by Department of Farm Power and Machinery, Dr. PDKV, Akola. Techno-economic performance evaluation of small Tractor operated folding type stubble collector was out carried during the study. Implement was tested in the field for maize and sorghum crop residues. Spacing between two adjacent tines was 10 cm. The working width was 180 cm and depth of operation was 5 cm. For stubble collection operation, average fuel consumption and average tractor wheel slip of the machine were found 3.21 lit/ha and 7.75 per cent respectively The effective field capacity, theoretical field capacity and field efficiency of implement was found to be 0.29 ha/h, 0.39 ha/h and 75.91 per cent respectively. The average collection efficiency was found to be 83.61 and 78.96 per cent. The cost of operation for stubble collection was Rs. 816.49/ha. The overall performance of the small tractor operated folding type stubble collector during the operation of stubble collection was found to be satisfactory.

Keywords: Field capacity, field efficiency, fuel consumption, stubble collection efficiency

1. Introduction
Now a day's stubble collection is done by the traditional methods such as manually collecting after ploughing or harrowing operation. This operation is done with the help of women, child labor etc. Such types of operation required more labor and time to consume and increases the cost of operation. Techno-economic performance evaluation of small tractor operated folding type stubble collector could fulfill the mechanization gap between the ploughing, harrowing and sowing operation at the faster rate.

2. Methodology
Specification of Machine
a) Size of implement without folding was 1800x500x50 mm. with folding was 1000x500x50 mm.
b) Length of tines was 450 mm.
c) Spacing between two adjacent tines was 100 mm.

2.1 Experimental technique
2.1.1 Soil parameters
a. Moisture content of the soil
b. Bulk density of soil

2.1.2 Machine and operational parameters
a. Speed of operation
b. Draft requirement
c. Theoretical field capacity
d. Effective field capacity
e. Field efficiency
f. Fuel consumption
g. Tractor wheel slip
h. Stubble collection efficiency
i. Wear analysis of the tines

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

a. Soil moisture content

Soil moisture content on dry basis was measured as suggested by Mohsenin (1979) [7] using oven dry method. The moisture content on dry basis was calculated using following formula.

$$\text{Moisture content, (db)} = \frac{W1-W2}{W2} \text{x } 100$$

Where,
W1= initial weight of soil sample, gm
W2= weight of dry soil sample, gm

b. Bulk density

It is the ratio of mass of soil sample to the volume of core cutter. The bulk density of soil was calculated by following formula.

$$\text{Bulk density (gm /cm3)} = \frac{\text{Mass of soil sample}}{\text{Volume of core cutter}} = \frac{M}{\pi D^2 L}$$

Where,
ρ = bulk density, gm/cm^3
M = borne dry weight of soil sample, gm
D = diameter of cylindrical core sampler, cm
L = length of cylindrical core sampler, cm

c. 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

d. Draft of 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].

$$\text{Draft of Implement} = \text{With load draft} - \text{Without load draft}$$

e. Theoretical field capacity

For calculating the theoretical filed capacity, working width and travelling speed was taken in to consideration. It is always greater than the actual field capacity. Theoretical field capacity was calculated by using following formula (Mehta *et al.*, 2005) [6].

$$\text{TFC} = \frac{\text{S x W}}{10}$$

Where,
TFC = theoretical field capacity, ha/h
W = theoretical Width of Implement, m
S = Speed of operation (km/h)

f. Effective field capacity

Effective actual field capacity was calculated by following formula (Mehta *et al.*, 2005) [6].

$$\text{EFC} = \frac{\text{A}}{\text{Tp+T1}}$$

Where,
EFC = 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)

g. 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 (Mehta *et al.*, 2005) [6].

$$\text{Field efficiency}(\%) = \frac{\text{EFC}}{TFC} \text{x} 100$$

Where,
EFC = effective field capacity, ha/h
TFC = theoretical field capacity, ha/h

h. Fuel consumption

To measure the fuel consumption, the tractor was placed on leveled ground. Then fuel tank of tractor was filled up to top of the tank before operation. After the completion of the operation tractor was placed at a leveled ground and then tank was again filled with fuel to maintain the original level of fuel. Quantity of fuel filled in the tank was measured by measuring cylinder. The quantity of fuel required to make up the original level as before the operation was the actual fuel consumption.

i. Tractor wheel slip

The tractor drive wheel normally slips in all field operations. The tractor wheel slip depends upon depth of operation and moisture content of the soil. The tractor wheel slip was determined in percentage by using following formula.

$$\text{Wheel slip, (\%)} = \frac{\text{N2}-\text{N1}}{\text{N2}}$$

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

j. Stubble collection efficiency

The stubble collection efficiency will be calculated by using the following formula

$$\text{SCE} = \frac{\text{SI}_1 - \text{SI}_2}{\text{SI}_1} \text{x} 100 \quad \ldots 3.21$$

Where,
SCE= Stubble collection efficiency, %
SI_1= Stubble Intensity per m^2 area before operation
SI_2= Stubble intensity per m^2 area after operation

2.2 Cost Economics of small tractor operated folding type stubble collector

The cost of operation of small tractor operated folding type stubble collector is the addition of cost of operation of tractor and cost of operation of the implement. The cost operation was calculated using the standard procedure. The total cost of operation per hour consists of fixed cost and operating cost.

fixed cost includes depreciation, interest, housing, insurance and taxes. operating cost includes fuel cost, lubricant cost, repair and maintenance cost and wages. Total cost (Fixed cost + Operating cost)

3. Results 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 4 ha area was selected for performance of machine.

Experimental results

SN	Particulars	Field I	field II
1	Size of plot, m^2	200x200	200x200
2	Depth of operation, cm	5.00	5.00
3	Forward speed, km/h	2.15	2.27
4	Effective field capacity, ha/h	0.29	0.29
5	Theoretical field capacity, ha/h	0.38	0.40
6	Field efficiency, %	79.08	76.08
7	Draft requirement, kgf	175.50	159.50
8	Fuel consumption, l/h	3.25	3.18
9	Wheel slippage, %	6.68	8.83
10	Collection efficiency, %	83.61	78.97

3.1 Moisture content of the soil

The average moisture content of the soil at the time of stubble collection was found at 5 per cent.

3.2 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 1.34 gm/cm^3.

3.3 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

3.4 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 167.5kgf at an average speed of 2.21 km/h.

3.5 Theoretical Field Capacity

The theoretical field capacity of machine for trial was found to be 0.39 ha/h. Theoretical field capacity depends upon the speed of operation and theoretical width covered by the implement.

3.6 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 0.29 ha/h respectively.

Fig 1: Stubble collector during field trial

3.7 Field Efficiency

The average field efficiency of the machine for maize and sorghum stubble was found to be 79.08 and 76.08 per cent respectively. The field efficiency was decreased with increase in speed of machine as shown in fig. 1 and fig. 2

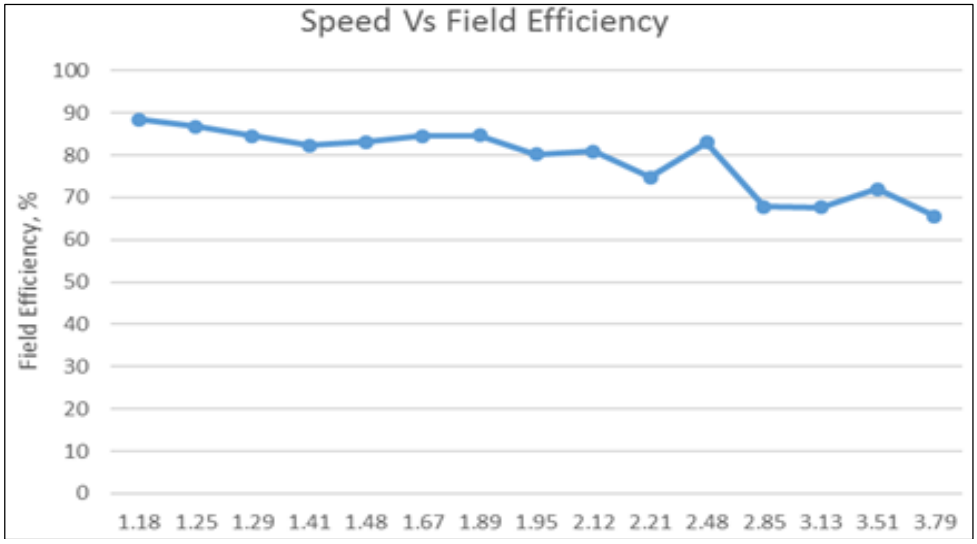

Fig 1: Speed versus field efficiency for maize stubble

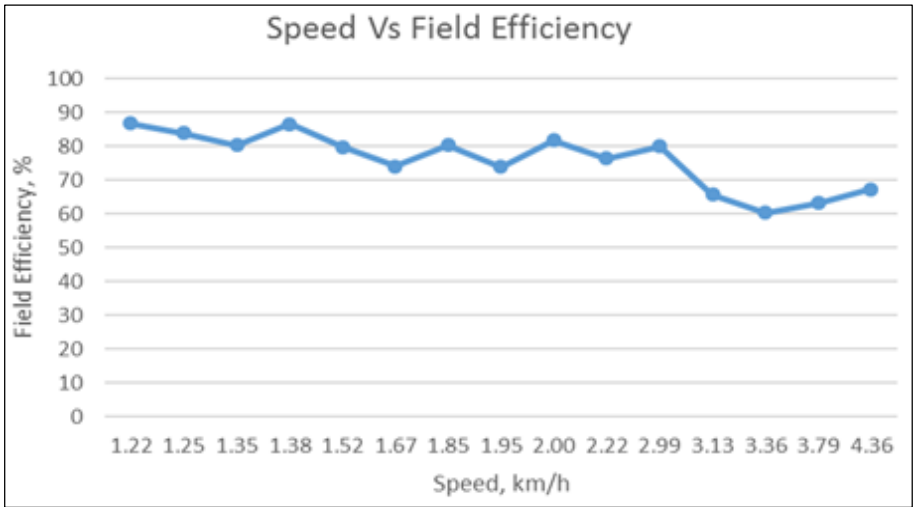

Fig 2: Speed versus field efficiency for Sorghum stubble

The above fig.1 shows the speed versus field efficiency of machine. It shows that the field efficiency was decreases with increase in the speed of machine. The maximum field efficiency 88.43 per cent was found to be a speed of machine was 1.18 km/h and the above fig.2 shows the speed versus field efficiency of machine for sorghum stubble. It also shows that the field efficiency was decreases with increase in the speed of machine. The maximum field efficiency 86.76 per cent was found to be a speed of machine was 1.22 km/h.

3.8 Fuel consumption
The average fuel consumption of machine for maize and sorghum stubble was found to be 3.25 lit/ha and 3.18 lit/ha.

3.9 Tractor wheel slip
The average wheel slip of the tractor for operation of maize stubble collection and sorghum stubble collection was found to be 6.68 and 8.83 per cent.

3.10 Stubble collection efficiency
The stubble collection efficiency was calculated on the basis of observations number of stubbles before and after the operation. Average stubble collection efficiency was found to be 83.61 and 78.97 per cent for maize and sorghum stubble collection operation.

a) before operation b) after operation

Fig 2: Field before and after the operation

3.11 Cost of operation per hectare of small tractor operated folding type stubble collector
The cost of operation per hectare of small tractor operated folding type stubble collector 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. 816.49 per ha.

4 Conclusions
The performance of the stubble collector was evaluated in terms of field efficiency, stubble collection efficiency and cost economics. 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 of stubble collector. The type of soil was heavy clay soil where experiments were conducted.
The effective field capacity of stubble collector was found to be 2.32 ha/day. The maximum field efficiency and stubble collection efficiency was found to be 79.08 per cent and 83.61 per cent on maize stubble field respectively. The saving in cost and time were 85 per cent and 75 per cent, respectively as compare to traditional method of stubble collection. The overall performance of the small tractor operated folding type stubble collector during the operation was found to be satisfactory.

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