Performance evaluation of self propelled vertical conveyor reaper for soybean crop

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■ **ABSTRACT :** The feasibility testing of self propelled vertical conveyor reaper was carried out for harvesting of soybean crop at Central Research Station of Dr.PDKV, Akola. The testing was carried as per RNAM test codes on four test plot of total area 1.1 ha. The average effective field capacity and field efficiency of the self propelled vertical conveyor reaper was found to be 0.255 ha/h and 88.59 per cent, respectively. Fuel consumption of self propelled vertical conveyor reaper was 0.728 l/h, and 2.84 l/ha The average harvesting losses in mechanical harvesting and manual harvesting were found to be 5.68 per cent and 4.73 per cent, respectively.The cost of operation of self propelled vertical conveyor reaper and manual harvesting were 775.64 Rs/ha and 1264 Rs/ha, respectively. In mechanical harvesting the per cent saving in the cost of operation and time were found to be 38.63 per cent and 67.81 per cent, respectively.

■ **KEY WORDS :** Self propelled vertical conveyor reaper, Harvesting Losses, Shattering losses

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Agricultural mechanization refers to interjection of improved tools, implements and machines between farm workers and materials handled by them. Independent India ushered in a process of agricultural mechanization and revival of rural agro processing which got acceleration during post-green revolution period. Currently mechanization is in increasing demand.

Soybean is known as the "golden bean" of the 20th Century. Though soybean is a legume crop, yet it is widely used as oilseed. It is now the second largest oilseed in India after groundnut. It grows in varied agro-climatic conditions. It has emerged as one of the important commercial crop in many countries.

USA is the major producer of soybean and ranks first in production. India occupies fifth place. During the year 2008-2009 the area under soybean crop in India was 9.51 million hectares, with the production of 9.91 million tones.

Madhya Pradesh, Maharashtra and Rajasthan accounted for 59.6 per cent, 27.83 per cent and 8.13 per cent production, respectively during the year 2008-09 covering an area of 53.88 per cent, 32.21 per cent and 8.72 per cent in India (Source: Directorate of Economics and Statistics, Department of Agriculture and Cooperation, 2010).

Soybean harvesting is carried out manually in most parts of our country. Harvesting is one of the important operations of farming. This is a labour intensive seasonal operation consuming about 18-20 % of the labour required for growing cereal crops (Singh *et al*. 2008).

Mechanization of harvesting is an alternative solution. Combine harvesters are also used in some parts of country but are faced with limitation of small soybean fields and intercropping. Reaper harvesters on the other hand are other alternative harvesting equipment, provided straw is considered as economic by-product for animal feed and/or industrial applications (Singh, 2002).

The self propelled vertical conveyor reaper is an engine operated, walk behind type harvester suitable for harvesting and windrowing cereals crops. The reaper consists of engine, power transmission box, lugged wheels, cutter bar, crop row dividers, conveyor belts with lugs, star wheels, operating controls and a sturdy frame.

Considering the labour shortage during peak harvesting period, risk of damage to the crop due to untimely rains, short time availability for land preparation and sowing of *Rabi* season crop it becomes essential to mechanize the harvesting of soybean crop. Keeping in view the above facts

the project on feasibility testing of self propelled vertical conveyor reaper for harvesting of soybean crop was carried out with following objectives.

– To evaluate performance of self propelled vertical conveyor reaper for soybean crop.

– To study the economics of use of self propelled vertical conveyor reaper for soybean crop.

■ METHODOLOGY

The testing of self propelled vertical conveyor reaper was carried out at Malkapur block and Gudhi block of central research station of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. for harvesting soybean crop in the month of October 2011.

Sr. No.	Particulars	Specification
Table A : Constructional details and specifications of self propelled vertical conveyor reaper		
1.	Power source	5 hp, diesel engine
2.	Width of cutter bar, cm	120
3.	Size of reaper: Length x width, cm	245 ×150
4.	Height of reaper, cm	110

Performance evaluation of self propelled vertical conveyor reaper.

The performance of self propelled vertical conveyor reaper was evaluated by taking the field tests, as per RNAM test code. The following parameters were measured during harvesting of soybean crop.

Speed of operation (forward speed) :

The speed of operation of reaper was calculated by using following formula :

$$\text{Speed (km/h)} = \frac{\text{Distance covered (m)}}{\text{Time reqired to cover that distance (sec)}} \times 3.6$$

Effective field capacity:

Effective field capacity was calculated as

$$\text{Effective field capacity (ha/h)} = \frac{A}{T_P + T_1}$$

where,

A = Area covered, ha

T_p = Productive time, h

T_1 = Non productive time, h (time lost for turning, cleaning, adjustment of machine).

Theoretical field capacity :

$$\text{Theoretical field capacity (ha/h)} = \frac{S \times W}{10}$$

where,

S = Speed of travel, km/h

W = Theoretical width of implement, m.

Field efficiency :

Field efficiency was calculated as

$$\text{Field efficiency (\%)} = \frac{\text{Effective field capacity (ha/h)}}{\text{Theoretical field capacity (ha/h)}} \times 100$$

Fuel consumption :

The fuel tank of reaper was filled up to top of the tank before the test starts. After the completion of the harvesting operation reaper was parked at some leveled location and then tank was again filled with fuel to maintain the original level of fuel. The quantity of fuel required to make up the original level as before the operation was actual fuel consumption.

Harvesting losses :

Total Harvesting losses include the pre harvest losses, shattering losses and uncut losses. The total losses were determined by the following equation.

$$W_{gt} = W_{g1} + W_{g2} + W_{g3}$$

where,

W_{gt} = Total losses (g/m²)

W_{g1} = Pre harvest losses (g/m²)

W_{g2} = Shattering losses (g/m²)

W_{g3} = Uncut losses (g/m²)

Shattering losses:

It includes shelled soybeans and detached soybean pods that are shattered from stalks by the cutter bar of reaper.

Uncut losses :

It includes the soybean remaining in uncut pod and plants when the reaper harvests the crop.

Percentage of harvest losses :

After measuring the amount of losses at different stages, the percentage of harvest losses are determined by the following equation :

$$H = \frac{Wgt - Wg1}{Yg} \times 100$$

where,

Y_g = Grain yield (g/m²).

Cost economics of self propelled vertical conveyor reaper :

The total cost of operation per hour consists of fixed cost and operating cost.

Fixed cost per hour :
– Depreciation
– Interest per hour
– Housing.

Variable cost:
– Fuel cost
– Lubricants cost
– Repair and maintenance cost per hour
– Wages of operator per hour.

Determination of cost of operation per hectare for vertical conveyor reaper

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

■ RESULTS AND DISCUSSION

The results of the present study as well as relevant discussions have been presented under following sub heads:

Field testing of self propelled vertical conveyor reaper:

Performance evaluation of the self propelled vertical conveyor reaper was done to test its feasibility for harvesting of soybean crop. Trials were conducted on four test plots of total area 1.1 ha.

Test condition and other details for mechanical and manual harvesting of soybean crop:

The average height of plant, row spacing and plant to plant spacing of soybean crop in mechanical harvesting was observed to be 50.47 cm, 45 cm, and 5 cm, respectively. The average plant density (number/m²) was observed to be 56.25. The height of cut was observed to be 10.2 cm.

The average height of plant, row spacing and hill spacing of soybean crop in manual harvesting was observed to be 50.65 cm, 45 cm, and 5.1 cm, respectively. The height of cut was observed to be 9.8 cm.

Grain and straw moisture content :

The average grain moisture content for the 4 test plot was 9.69 per cent. The moisture content of stalks of soybean was also determined. It was observed that the average straw moisture content at the time of harvesting was 8.5 per cent.

Field performance of self propelled vertical conveyor reaper :

Field performance of self propelled vertical conveyor reaper depends upon measures like total operating time, cutting width, forward speed, effective field capacity and field efficiency. The harvesting of soybean crop by self propelled vertical conveyor reaper was carried out on total area of 1.1 ha, while manual harvesting was carried out on area of 0.18 ha.

Theoretical field capacity :

As the average forward speed of reaper during operation was 2.4 km/h and the total working width of the same was 1.2 m. The theoretical field capacity of the reaper was found to be 0.288 ha/h (Table 2).

Effective field capacity :

Total area covered by the reaper was observed to be 1.1 ha and time required to cover this much of area by the reaper was around 4.4 hours. The calculations revealed that the effective field capacity was 0.25 ha/h. The average effective field capacity in manual harvesting with 7 number of labours was observed to be 0.082 ha/h (Table 1).

Field efficiency :

The average field efficiency of self propelled vertical conveyor reaper was observed to be 88.59 per cent (Table 2).

Labour requirement :

The average labour requirement for harvesting of soybean crop by self propelled vertical conveyor reaper was observed to be 3.91 man hours per hectare. In case manual harvesting the labour requirement was observed to be 85.1 man hours per hectare (Table 1 and 2).

Fuel consumption :

The average fuel consumption of the self propelled vertical conveyor reaper to harvest the soybean crop was found to be 0.728 l/hr or 2.84 l/ha (Table 2).

Harvesting losses :

The measured values of preharvest, shattering and

Table 1 : Field performance results of manual harvesting				
Sr. No.	Parameters	Test 1	Test 2	Avg.
1.	Number of labours	7	7	-
2.	Actual area covered (ha)	0.105	0.080	-
3.	Labour requirement, man-hr/ha	89.74	80.45	85.1
4.	Total time of operation (min)	80	55	-
5.	Effective field capacity (ha/hr)	0.078	0.087	0.0825

harvesting losses in manual and reaper methods are shown in Table 3 and 4. The results revealed that the preharvest losses were considerable and the harvesting was carried out at lower moisture content than normal limit. Delay in harvesting caused grains to shatter due to natural factors (wind) and, therefore, preharvest losses increases.

Shattering losses :

The average shattering losses in mechanical harvesting and manual harvesting was observed to be 5.12 per cent and 4.31 per cent, respectively. From Table 4 it is observed that when the grain moisture content was 10.5 per cent, 9.58 per cent, 9.57 per cent and 9.12 per cent; the corresponding values of shattering losses were 4.34 per cent, 5.12 per cent, 5.20 per cent, and 5.84 per cent, respectively. It can be concluded that the shattering losses increased with decreased in the grain moisture content.

Harvesting losses :

Harvesting losses includes shattering losses and uncut losses. The average uncut losses in manual and mechanical

harvesting were observed to be 1.05 g/m^2 and 1.53 g/m^2, respectively. The average harvesting losses in manual and mechanical harvesting was observed to be 4.73 per cent and 5.68 per cent, respectively (Table 3 and 4).

Summary and conclusion:

From the analysis of the results the following can be concluded:

– The effective field capacity of the reaper for soybean harvesting was 0.255 ha/h compared to 0.082 ha/h.in manual operation.

– The average labour requirements for reaper and manual harvesting were 3.91 and 85.1 man-h/ha, respectively. Therefore, in fields where the use of reaper is possible, it will play an important role in reducing production costs.

– The average harvesting losses in mechanical harvesting and manual harvesting were found to be 5.68 per cent and 4.73 per cent, respectively.

– The cost of operation for harvesting of soybean crop with self propelled vertical conveyor reaper and manual harvesting were 775.64 Rs/ha and 1264 Rs/ha, respectively.

Table 2 : Field performance results of self propelled vertical conveyor reaper						
Sr. No	Parameters	Test plot no.				
		1	2	3	4	Avg
1.	Actual area covered, ha	0.105	0.370	0.380	0.240	-
2.	Total time of operation, min	26	82	90	56	-
3.	Effective working Width, cm	118	119	118	117	118
4.	Forward speed, Km/h	2.3	2.5	2.4	2.4	2.4
5.	Theoretical field capacity, ha/h	0.276	0.30	0.288	0.288	0.288
6.	Effective field capacity, ha/h	0.241	0.270	0.253	0.257	0.255
7.	Field efficiency, per cent	87.31	90	87.84	89.23	88.59
8.	Labour requirement, man-hr/ha	4.14	3.70	3.92	3.89	3.91
9.	Fuel consumption, lit/ha.	2.91	2.69	2.90	2.87	2.84
10.	Fuel consumption (lit/h)	0.705	0.728	0.742	0.738	0.728

Table 3 : Harvesting losses in manual harvesting						
Test plot no.	Grain m.c. %	Yg (g/m^2)	wg_1 (g/m^2)	wg_2 (g/m^2)	wg_3 (g/m^2)	Shattering losses (%)	Harvesting losses (%)
1	9.54	263	2.93	11.26	1.17	4.28	4.72
2	9.12	241	2.72	10.48	0.93	4.35	4.73
Avg.	9.33	252	2.82	10.87	1.05	4.31	4.73

Table 4 : Harvesting losses in mechanical harvesting						
Test plot no.	Grain m.c. %	Yg (g/m^2)	wg_1 (g/m^2)	wg_2 (g/m^2)	wg_3 (g/m^2)	Shattering losses (%)	Harvesting losses (%)
1	10.5	250	3.08	10.84	1.48	4.34	4.93
2	9.58	282	3.13	14.44	1.51	5.12	5.65
3	9.57	275	3.38	14.30	1.50	5.20	5.74
4	9.12	285	3.75	16.64	1.61	5.84	6.40
Avg.	9.69	273	3.33	14.05	1.53	5.12	5.68

– In mechanical harvesting, the per cent saving in the cost of operation and time were found to be 38.63 per cent and 67.81 per cent, respectively.

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