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Development of collection and unloading unit attachment for self propelled vertical conveyor reaper

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■ **ABSTRACT :** The self propelled vertical conveyor reaper for soybean crop was undertaken for modification with the objectives to develop collection and unloading unit attachment for self propelled vertical conveyor reaper for harvesting of soybean crop. The developed unit consists of collection box, unloading unit and ground wheel. In manual harvesting of soybean crop, the crop after harvesting, is collected at one place and stored in the heap form for further threshing. This process of collection and heap making is very laborious and drudgerious. In the view, the self propelled vertical conveyor reaper (SPVCR) was tested for its field performance for harvesting of soybean crop. Based on the field tests, a work of development of collection and unloading unit attachment for SPVCR was carried out. The unit was developed for collection and unloading of harvested soybean crop at every 5 m distance of travel. The effective field capacity of SPVCR was found to be 0.255 ha/hr with field efficiency of 88.78 per cent. The cost operation was 773.78 Rs./hr. Laboratory trials of unit were conducted and found satisfactory. Also the test results of mechanical harvesting of soybean crop by SPVCR were compared with test results of manual harvesting for to determine the benefits of mechanical harvesting over manual harvesting. The SPVCR cut and windrowed cut crop of soybean uniformly in a row. Fuel consumption of SPVCR was 2.81 lt./ha. The average harvesting losses in mechanical harvesting and manual harvesting were found to be 3.55 per cent and 3.42 per cent, respectively.

■ **KEY WORDS :** Power unit, Transmission unit, Reaping, Conveying unit, Collection, Unloading unit

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Soybean (*Glycine max*) is one of the most valuable crops in the world not only as an oil seed crop and feed for livestock and aquaculture, but also as a good source of protein for the human diet and as a biofuel feedstock it cannot be utilized as a pulse. It is now the second largest oilseed in India after groundnut. Soybean has great potential as an exceptionally nutritive and very rich protein food. It can supply the much needed protein to human diets, because it contains above 40 per cent protein of superior quality and all the essential amino acids particularly glycine, tryptophan and lysine, similar to cow's milk and animal proteins. Soybean also contains about 20 per cent oil with an important fatty acid, lecithin and vitamin A and D. The 4 per cent mineral salts of soybeans are fairly rich in phosphorus and calcium. The most versatile of the world's major crops, soybeans can be grown in a wider variety of soil and agro-climatic conditions than any other major world crop.

Soybean is grown on an estimated 6 per cent of the world's arable land. USA is the major producer of soybean and ranks first in production. Its share in the world production is almost 35 per cent. Brazil, Argentina and China rank second, third and fourth position in terms of production, respectively. India occupies fifth place. During the year 2011-12 the area under soybean crop in India was 10.69 million hectares, with the production of 12.67 million tones. In the recent past, soybean cultivation has increased many folds as compared to any other oil seed crop in the country and stands next to groundnut, though commercial production of soybean began in 1971-72. Madhya Pradesh, Maharashtra and Rajasthan accounted for 54.35 per cent, 30 per cent and 8.13 per cent production, respectively during the year 2011-12 covering an area of 53.88 per cent, 32.21 per cent and 9.23 per cent in India (Anonymous, 2011). In manual harvesting of soybean crop, the crop after harvesting, is collected at one place and stored in the heap form for further threshing. This process of collection and heap making is very laborious. In the view to overcome the problem of collection and heap making manually, development of collection and unloading unit is done in SPVCR.

METHODOLOGY

The methodology and experimental techniques were adopted in study for development of collection and unloading unit for SPVCR. This paper gives an account of constructional details of different components along with their specifications, modification done, etc.

The specifications of self propelled vertical conveyor reaper and engine are given in Table A.

The reaper was divided into four main sub assemblies as frame, power unit (diesel engine), transmission system, and reaping and conveying unit. The constructional details of SPVCR used as follows.

Frame :

The engine, gear box and handle of reaper were mounted on the frame of self propelled reaper. Frame was fabricated from MS angles of size 35 × 35 × 5 mm. The frame was made capable in order to bear the weight of gear box, reaping unit and the engine. Engine was fitted on the frame with the help of MS plate of size 280 × 280 × 5 mm. MS pipes of diameter 22 mm were used as handles. The handle was fitted on the frame with MS pipe of diameter 42 mm. The handle height of reaper was adjustable to suit the operator.

Power unit :

5 hp diesel engine was used as power source in self propelled vertical conveyor reaper. Engine was fitted on the frame with the help of MS plate of size 280 × 280 × 5 mm.

Transmission system :

Power from the engine to the drive wheel was transmitted through combination of v-belt drive, chain and sprocket mechanism. The diameter of pulley mounted on the engine shaft was 50 mm. It has 3 V grooves. The pulley on engine shaft was connected to the pulley of diameter 240 mm which drives chain and sprocket mechanism of drive wheels. The centre to centre distance between these two pulleys was 380 mm and V belt was used to connecting them. Power is then transmitted to the axle of lug wheels through chain and sprocket drive. Lug wheels were made up of MS angles having 12 numbers of lugs and 6 numbers of spokes. The width and diameter of lug wheel was 125 mm and 505 mm, respectively. The speed ratio between engine pulley and drive wheel was 105:1 *i.e.* after 105 revolutions of engine pulley the drive wheel completes its one revolution.

The power from engine to the reaping unit was transmitted through the belt drive. The pulley of diameter

Table A : Specification of self propelled vertical conveyor reaper and engine

Sr. No.	Particulars	Specification
1.	Power source	5 hp, diesel engine
2.	Width of cutter bar, cm	120
3.	Size of reaper: length × width, cm	245 × 150
4.	Height of reaper, cm (from ground to handle)	110
5.	Engine type (diesel engine)	Single cylinder, 4 stroke
6.	Make	Greaves cotton
7.	Maximum power, hp	5 hp

96 mm was fitted on chain and sprocket shaft. It was connected to the pulley mounted on gear box of reaping unit through belt drive. Small gear box with two bevel gears was fitted to the reaping unit to transfer the power in right angle. As the bevel gears have same number of teeth, therefore, the speed ratio was 1:1. The diameter of pulley on the gear box of reaping unit was 75 mm.

Reaping and conveying unit :

Reaping unit was consisted of cutter bar, crop divider, star wheel and pair of lugged conveyor belt (Fig. A). Reaping unit cut the crop and conveyed vertically to one end and windrowed in the uniform swath on the ground uniformly. Cutter bar cut the crop by impact and shear action between knives and finger guard. The reciprocation of cutter bar was achieved by the motion from pitman arm. Pitman arm converted the rotary motion into reciprocating motion. Cutter bar was having 7.2 cm stroke length. There were two strokes per revolution of the crank. Total length of cutter bar was 1.2 m. Cutter bar and blades were made of cast iron and medium carbon steel, respectively.

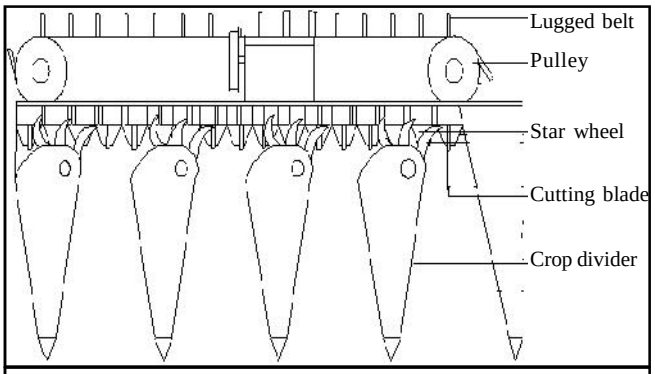

Fig. A : Reaping unit of self propelled vertical conveyor reaper

During harvesting, the crop divider enters the standing crop, guides it towards the cutter bar. Lugged belt was powered from reaping unit gear box by chain and sprocket. Total length of belt was 3.04 m and lug pitch was 14.5 cm with 21 lugs. The belt and lugs were made of canvas and plastic, respectively. The cut crop was conveyed to one side by the lugged conveyor belt and star wheels vertically. The star wheels were made of plastic fitted at 22° inclinations. The diameter of star wheel was 28 cm. star wheels are rotated by the lugs of conveyor belt.

Collection and unloading unit :

Collection and unloading unit was developed for to collect the cut crop of soybean and unload it on the ground at regular interval of travel *i.e.* at 5 m distance of travel (Fig. B). A collection and unloading unit was designed for storing a mass of soybean plants collected from 6 m^2 area. The collecting unit was designed for storing the crop from 5 meter distance travelled in the field. At the end of 5 meter distance the collected crop to be unloaded from the box by unloading mechanism. The size of heap of soybean crop harvested from 5 meter length and cutting width of reaper of 1.2 meter comes to 75 × 60 × 45 cm^3. Unloading unit consist unloading fingers mounted on shaft, chain and sprockest.

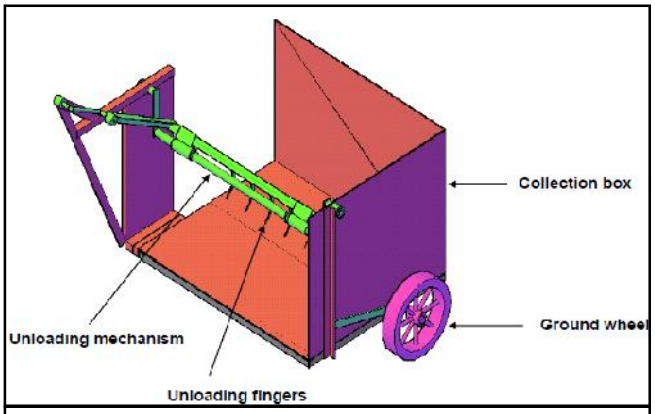

Fig. B : Isometric view of collection and unloading unit

This unit may be helpful for collection and heap making operation *i.e.* carried out by manually. With the help of this unit may reduce the human drudgery and efforts.

Constructional details and specifications of collection and unloading unit :

Specifications of self propelled vertical conveyor reaper attached collection and unloading unit are given in Table B.

Size and volume :

The volume of a rectangular unit is length x width x height. Average size of rectangular unit is considered according to dimensional parameters of average soybean. The size of heap of soybean crop harvested from 5 meter length and cutting width of reaper of 1.2 meter comes to 75 × 60 × 45 cm^3.

Frame :

The frames of collection and unloading unit hold all parts together for efficient functioning. Frame size is rectangular which was made by M.S. angle of size 25 × 25 × 4 mm and it provides structural stability. Size of rectangular frame is 750 × 600 mm.

Ground wheel :

Ground wheel was provided on the outer side of the collection and unloading unit for stabilizing weight of collecting unit and moving forward in direction of travel. The diameter of ground wheel was 210 mm to achieve required height of cutting and ground clearance. The diameter and length of ground wheel shaft was 20 × 95 mm, respectively.

Unloading mechanism :

Unloading mechanism provided was self unloading gear type mechanism for unloading the cut material at 5m distance in path. Unloading mechanism consist of unloading fingers as like a sickle was attached on the unloading shaft. Unloading mechanism was eccentric type, it consist hollow rod of diameter and length 22 × 730 mm, respectively on which bearing was fitted. L type angle is cut and it was attached on bearing of size 6.5 × 3.8 × 7 mm. M.S flat of 690 × 25 × 7 mm was attached on L type angle on which unloading finger was welded and made of M.S. flat of size 380 × 30 × 4 mm for completing eccentric motion one 'z' type rod of diameter 10 mm was also used along with two bearings of diameter 30 mm. The drive to operate unloading mechanism was taken from right ground wheel of vertical conveyor reaper by means of chain and sprocket drive. It was operated after equal interval of time and pushes all collected volume of crop in the row in the form of heap.

Driving mechanism :

Drive to operate unloading mechanism was taken from the right side wheel of the reaper with the help of chain and sprocket mechanism to drive the unloading mechanism. The diameter of the ground wheel was 500 mm. The chain drive was preferred for operating unloading mechanism because it transmitted positive and efficient drive. The sprocket was used of size 3/8" pitch. The shaft 25 mm was used in the driving mechanism connected to chain and sprocket mechanism. The chain drive drives the gear mechanism which was finally connected to unloading mechanism. The gear was used in this mechanism is spur type of 19 teeth, and 3:1 gear velocity ratio. To operate the unloading mechanism after equal interval of time *i.e.* 5 m distance of travel. The teeth on larger size gear were removed from 51 to 19 teeth.

Laboratory testing of collection and unloading unit:

Developed collection and unloading unit was tested in the laboratory of Department of Farm Power and Machinery, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, regarding the working of its component parts such as collection and unloading mechanism. To evaluate the performance of collection and unloading unit in the

Table B : Constructional details of collection and unloading unit

Sr. No	Components	Material used	Shape	Size/ Dimensions, mm	Quantity
1.	**Collection unit**				
	Frame	M. S. angle	Rectangular	750 × 600	1
	Box	M. S. sheet	Rectangular	750 × 600 × 2, 600 × 480 × 2, 750 × 480 × 2	1
	Ground wheel	M. S. bar and M.S. flat	Circular	210 × 50	1
2.	**Unloading mechanism**				
	Unloading shaft	M. S. pipe	Circular	360 × 22	1
	Bearings	M. S. bar	Circular	32 × 50	2
	L type plate	M. S. angle	L type	65 × 38 × 4	2
	Supporting plate	M.S. flat	Rectangular	690 × 30 × 4	1
	Unloading fingers	M.S. flat	Sickle type	380 × 15 × 2	9
3.	**Driving mechanism**				
	Reaper ground wheel	M. S. bar, M.S. flat	Circular	500 mm	1
	Chain and sprocket	Mild steel	Roller type	3/8"	2
	Gear	High carbon steel	Spur type gear	3/8" 19 teeth 3:1 speed ratio	2

laboratory following procedure was carried out.

- Developed collection and unloading unit attached to the vertical conveyor reaper and this whole assembly put on the raised platform in such a manner that the ground wheels are free to move.
- During lab trial the working lever was engaged and the number of revolution of ground wheel of VCR completed for operating ones the unloading mechanism were counted.
- The cut material of grass or hay resembling soybean crop was fed in to the reaping and conveying unit of VCR, whether it conveyed the cut crop in to the collection box and unloads it on the ground at equal interval of time *i.e.* 5 m distance of travel was checked. The travel distance was calculated by measuring the number of revolution of ground wheel of VCR and its circumference.

Mechanical damage caused to the unloading mechanism:

It was conducted to determine if any mechanical damage occurred to unloading mechanism during laboratory test.

RESULTS AND DISCUSSION

The self propelled vertical conveyor reaper (SPVCR) was tested in the laboratory as well as in the field to evaluate its overall performance. The laboratory tests were conducted in workshop of Department of Farm Power and Machinery, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The laboratory test was carried out to study the functional performance of component parts of the reaper. The field trials were conducted at the field of Malkapur block and Gudhi block, of Central Research Station, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola.

Collection and unloading unit :

Collection and unloading unit was developed to collect the cut crop of soybean and unload it on the ground at regular interval of time *i.e.* at 5 m distance of travel. It is observed that functional parts of collection and unloading unit were working satisfactorily during laboratory testing. This will be helpful for collection and heap making operation *i.e.* carried out by manually. With the help of developed unit may reduce the human drudgery and efforts. It may helps to avoid excess number of labours required for harvesting operation and that will reduce cost of operation.

Performance evaluation of collection and unloading unit in laboratory :

The function of this unit is to collect and pushes down the cut crop in the form of small heaps at every 5 m distance of travel. The collecting and unloading unit was tested in laboratory of Department of Farm Power and Machinery, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola Regarding the working of its component parts such as driving and unloading mechanism and its sub parts and it was found that the components were working satisfactory.

Filler trial of collection and unloading mechanism in the field :

To evaluate field performance the filler trial of collection and unloading unit had been carried out on field of wheat crop. During this field trial it was observed that reaper cut, convey and throw the cut crop properly in to collection unit and at regular interval of time *i.e.* 5 m distance of travel, unloading unit pushes down all cut material on the ground in the form of small heaps.

Due to undulating field conditions, the VCR along with collection and unloading unit was not properly worked in to the field. The ground wheel of collection and unloading unit slightly sink in to the soil that increases the soil résistance. The effect of that is whole unit pulled towards one side. Similar to present investigation several workers also conducted successful experiments with reapers (Bansal, 1992; Devnani and Howson, 1981; Mohammad *et al.*, 2007; Mehetre *et al.*, 2014; Dange *et al.*, 2013; Gajakos *et al.*, 2013; Kurhekar and Patil, 2011 and Prasad *et al.*, 2007).

Summary and conclusion :

Collection of harvested crop by the reaper was carried out manually but its too difficult and time consuming operation. To overcome this problem development of collection and unloading unit was carried out. In which cut crop was collected and unloaded down cut crop on the ground at every 5 m distance, in the form of small heaps. This may be easy for labour to collect the cut crop and transport them in to the threshing yard. The average field efficiency of the self propelled

vertical conveyor reaper was found to be 88.78 per cent with the fuel consumption 2.81 lt./ha. The laboratory performance of developed collection and unloading unit was found to be satisfactory. The unloading mechanism of collection and unloading unit was operated actually at 4.71 m distance. The overall performance of reaper was observed to be satisfactory.

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