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Design and development of manually operated harvester for wheat crop

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Abstract
This machine is to help small-scale farmers to meet an increased demand for local grains, by designing a harvester machine to harvest grains more efficiently. Our research work will focusing on ease of harvesting operation to the small land holders for harvesting wheat crop in less time and at low cost. The machine includes handle, main frame, cutter bar, crop divider and lifter, star wheel, ground wheel and supporting wheel. Cutter bar operated directly by ground wheel power. The optimum forward speed of the machine to obtain maximum field capacity was 1.7 km/h. the effective field capacity of the machine was found to be 0.048 ha/h. the field efficiency was 71.2 %.

Keywords: Harvester, wheat, land holders

Introduction
Wheat is a dominant crop in temperate countries and is being used as human food and livestock feed. Wheat is an important source of carbohydrerads. The area of cultivation for wheat in the country was estimated to be approximately 30.6 million hectares, up from about 30.4 million hectares in fiscal year 2016. In india production of wheat estimated at 93.50 million tonnes during 2016-17, is higher by 6.97 million tonnes than the production of 86.53 million tonnes achieved during 2014-15.total production of coarse cereals estimated at 37.94 million tonnes is lower by 4.38 million tonnes than their production during 2014-15 (Annual report 2016-17).

Harvesting of crop is one of the important agricultural operations which demand considerable amount of labour. The availability and cost of labour during harvesting season are the serious problem. The shortage of labour during harvesting season and vagaries of weather causes great losses to the farmers. Many sickles was developed by the researchers for harvesting of crop. Oberoi & Singh (2001) [8] have identified the harvesting operation as the most prone tasks for drudgery. As harvesting is normally carried out in squatting/bending postures and also the relative workload is high, the workers get injured while operating sickles. Karunanithi and Tajuddin (2003) [5] have studied the women farmers in Coimbatore region in India while harvesting the paddy by local sickles and found the average working pulse-rate as120 beats/min. Gite and Agarwal (2000) have reported that while harvesting of wheat crops, the use of serrated sickles reduced the drudgery of women farmers by 16.5% as compared to local-sickles. P.B.Chavan *et al*. (2015) [3] have developed harvester for rice and wheat crop but not ergonomically tested and reported that its field efficiency was less that is 66 %. With a view to develop a manually harvester for the workers of Chhattisgarh for ease of work and to minimize the effect of machine on physiological response of workers.

Materials and methods
A manually operated harvester (Fig. 1) is developed in the Faculty of Agricultural Engineering, IGKV, Raipur, Chhattisgarh, Raipur. To develop the manually operated harvester various components were designed /selected as per the requirement with the used of anthropometry data for various parts of the design. The various components of developed harvester are discussed as below:
1. Power source
2. Power transmission unit
3. Crop cutting and crop conveying unit
4. Machine transporting unit
5. Frame

Power source: Human power is used as a power source to supply power to cutter bar and conveyor of the harvester. According to Campbell (1990) the power of useful work done by human being is given by

H.P. = 0.35-0.092 log t

Where,

t = time in minutes.

For four hours continuous work, H.P. developed by man = 0.13 hp
We know that,

$$HP = \frac{\text{Push (kg)} \times \text{Speed (m/sec)}}{75}$$

Studies of different strength parameters of the farm workers were selected forward speed was 1.35, 1.5 and 1.7 km/h.

Power transmission unit: The harvesting machine design with the chain sprocket power transmission system. In this machine human power direct transmitted to the ground wheel with the help of chain sprocket system. After that chain sprocket system operate four bar mechanism (cutter bar) and star wheel in same time. Cutter bar cut the crop and star wheel to guide the crop towards cutter bar.

Gear box: Gear box consists of spur gears received the human power through ground wheel and chain sprocket. Gear box mounted in the front of the harvester it's also increase the speed of the rotation of the crop conveyor and cutting unit.

Chain and sprocket: Chain sprockets were used for transfer power from one system to another system of harvester. In this machine different size of five sprocket are used 2 sprocket of 42 teeth and diameter 190 mm and 3 sprocket of 19 teeth and diameter 70 mm and two different chain was used. First sprocket was mounted on the ground wheel rotation shaft and second was mounted on the upper portion of the machine near to gear box.

Connecting arm: The connecting arm was used to join the cutter bar and ground wheel shaft.

Crop dividers and lifters: The row crop divider and lifter were provided to penetrate into standing crop and lift & guide the crop towards cutter bar for proper cutting or harvesting of crop. The row crop divider and lifter were mounted on the crop supporting unit. The spacing between row crop divider and lifter was 450 mm to obtain the maximum actual width of cut.

Star wheel: A star wheel was used for lifting as well as conveying the crop to the cutter bar of the machine. The star wheel directs the crop towards the cutter bar and help in turning at 90˚ to crop after cutting, which is then conveyed towards one side of the machine with the help of conveyor chain.

Main frame: The suitable frame of desired strength and according to the row spacing was fabricated to support the shaft which was attached to the ground wheel and handle. The frame was made of angle irons in the outer length and width of 920 mm and 470 mm respectively. The frame was made by joining four angle iron sections to get rectangular shape. The frame was dived into two parts. Front portion of the frame size was 350×470 mm to accommodate various components of the machine like gear box, ground wheels, crop cutting, conveying and supporting unit. Back side of the frame size 570×47 mm which are mounted handle of the machine and supporting wheel.

Design of Handle
The handle of the implement is designed on the basis of the working position of the operator. Pushing and pulling capability largely depends on a complex interaction of posture, shoe/floor friction and subject to anthropometry. If µ (coefficient of friction) between operator's shoe and the soil surface is 0.3, the push force exerted may be 20 kg. With µ of about 0.6 the push force capability may increase to about 30 kg. the person with large reach and high body weight can achieve high push force if also provided with high traction surface and enough space to lean. In the harvesting operation the value of µ ranges from 0.4 to 0.78.

Performance evaluation
The harvester is evaluated at field for its performance for wheat crops. The field evaluation of manually operated harvester was conducted in the experimental farm of IGKV, Raipur, Chhattisgarh. Performance of the harvester is indicated by the uniform cutting of the crop, field capacity, field efficiency.

Theoretical field capacity
Theoretical field capacity was measured based on the forward speed and the cutting width of the harvester. Theoretical field capacity was calculated by following formula (Hunt, 1995)

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

Where,
S = Speed of operation, km/h
W = Theoretical width covered, m

Effective field capacity
Effective field capacity was measured based on area covered and actual time, including turning loss time. It was determined using the following formula (Hunt, 1993):

$$\text{Effective field capacity } C_e \text{ (ha/h)} = \frac{A}{T}$$

Where,
A = Actual area covered, ha
T = Total time required to cover the area, h

Field efficiency
The term field efficiency is used to describe the efficiency of the machine in operation. Field efficiency was measured from the ratio of actual field capacity to theoretical field capacity of the reaper. It was determined using the following formula (Hunt, 1995):

$$\text{Field efficiency } F_e \text{ (\%)} = \frac{\text{Ce}}{\text{Ct}} \times 100$$

Where,
C_e = Effective field capacity, ha/h
C_t =Theoretical field capacity, ha/h

Results and Discussion

The performance data of the manually operated harvester is presented in table 2. The average field capacity of the machine is found to be 0.048 ha.h-1 at average speed of 1.7 km.h-1 for harvesting of wheat crop. The field efficiency is observed to be 71.2 per cent for wheat crop. Similar results were reported by chavan *et al.*, (2015) [3]. Field tests indicated that the man-hour requirement of harvester is 43.22 hectare h^{-1}. Heart rate and Oxygen consumption rate is also significant with 5% level of significant. As the machine is laterally balanced with equal distribution of weigh it can be handled easily by the operator. All these performance indices indicate that the developed harvester worked satisfactorily at field condition.

Table 1: Specification of crop cutting unit of manually operated reaper

S. No.	Particulars	Specification
1.	Type of cutter bar	Reciprocating knife section
2.	Length of cutter bar	350 mm
3.	Knife section 1.1 Type 1.2 Blade 1.3 Length × Height 1.4 Angle between cutting edge and axis of knife section (α) 1.5 Rack angle 1.6 Thickness of cutting edge 1.7 Pitch of serrations 1.8 Clearance between knife and twin guard 1.9 material	Standard trapezodial Serrated 60 mm × 85 mm 31^0 22^0 25-30 µm 1 to 1.2 mm 0.5 to 1.0 mm High carbon steel
4.	Knife back	M.S flat 25 × 5 mm
5.	Height of cutter bar above ground level	100mm for 31^0 bevel angle
6.	Cutter bar height adjusting wheel diameter	200 mm

Table 2: Field performance parameters

	Field performance parameters	Value
1	Forward speed	1.7 kmh^{-1}
2	Time required	43.22 hah^{-1}
3	Effective field capacity	0.048 hah^{-1}
4	Field efficiency	71.2 %

Fig 1: Manually operated harveater

Conclusion

Manually operated harvester work continuously and gives more efficiency performance of the machine. Conveying mechanism now helps to stop clogging and decreases the cutting losses. Continuous working leads to harvest crop in less time with minimum man power. Based on analysis of results following conclusion are drawn: The Manual operated reaper is high labor saving equipment. The cost of reaper is low so it is affordable to small farmers. The field efficiency is satisfactory.

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