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Original Research Article

Field Evaluation of a Portable Crop Harvester in Wheat Crop

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Wheat crop harvester, Portable Harvester and field performances

ABSTRACT

The study was undertaken to evaluate a portable crop harvester for the hilly region of Jammu & Kashmir state on wheat crop at Advanced Centre for Rainfed Agriculture (ACRA), Dhiansar, SKUAST-J, and Farmer's Field, Chatha. The performance was evaluated in the terms of harvesting losses (post-harvest losses), actual field capacity and field efficiency. The performance of portable harvester was also compared with the traditional method of harvesting by sickle in terms of post-harvest losses, actual field capacity, field efficiency, labor required and operational cost. The labour requirement of sickle was almost five times more as compared to the developed portable harvester.

Introduction

Jammu and Kashmir is a hilly state in India and is blessed naturally with agro-climatic regions suitable for cultivation of a wide range of crops. The level of farm mechanization in the state is very low and there is a need to enhance mechanization level in the state for better resource conservation, low input cost and higher efficiency. The farm power availability was 0.78 kW/ha only in the state (gross cropped area basis). The bottleneck in mechanization are non-availability of improved equipments, small and scattered land holdings, low investing capacity of the farmers and lack of awareness among farmers (Dixit *et al.,* 2014). India is the second largest producer of the wheat (*Triticum aestivum* L.) in the world after China. The area under wheat has increased from 28.03 million hectares in 2007-08 to 30.60 million hectares in 2016-17. India is an agriculture based country and more than 50 percent people depends on agriculture. The wheat production in the country has increased from 78.57 million tons in 2007-08 to an all-time record high of 98.51 million tons in 2016- 17. The increase in production has been due to the increase in area with irrigations facilities, seed treatment, better varieties and management of optimum harvesting time and reduction of harvesting losses (FAO, 2017). The harvesting of Paddy and wheat crop by manual method needs about 25 percent of the total labor requirement of the crop. Depending upon the crop yield, 120 to 250 man-hr is required for cutting, bundling and on-field stacking of one hectare of paddy field by using traditional sickle (Nadeem, 1983). The harvesting of field crop takes about 185-340 man-h/ha to cut and bundle paddy or wheat crop (Michael and Ojha, 1987). The harvesting operation alone needs 20 and 16% of total labour requirement for kharif and rabi, respectively (Sarkar, 2000). Due to the poor socio-economic conditions, most of farmers of the hilly region cannot afford to purchase high capacity crop harvesters. The cost of the tractor operated and self-propelled harvesters ranges between rupees one to six lakhs and the weight of the crop harvester ranges between 400 to 900 kg and are therefore not easily portable in the undulated and hilly regions of Jammu & Kashmir state.

Murthy (1989) fabricated a simple tractor mounted vertical conveyor reaper for harvesting the wheat crop. He reported that it had a capacity of 0.350-0.375 ha/h and was operated with about 20 horse power tractor. It could cut the crop at 7-8 cm above the ground and saved the straw and it could be adjusted to 60-80 cm to ground level for transportation.

Bukhari *et al.,* (1991) evaluated the reaper-windrower at two different wheat crop farms for grain losses and also compared with the conventional method of harvesting. The whole grain losses by manual harvesting was 84.9 kg/ha and 139.6 kg/ha. But by machine the average losses was 41.1 kg/ha and 48 kg/ha. The labor requirement was 60.4 man-h/ha and 58.5 man-h/ha.

Nalawade *et al.,* (2009) designed and developed a tractor operated jowar reaper windrower. Three conveyor belts were provided on the machine to simplify better conveying of the cut stalks. It had cutting width 2.2 m.

Handaka and Pitoyo (2011) modified a grass cutter into a small rice harvester by replacing the cutter blade with a rotary blade, adding a guider and a propeller and adding an operator belt. The modified small rice harvester had a 2 hp 6000 rpm engine, tested on 100 m^2 with a standard engine and the results showed that the modified machine had a working field capacity of 0.05 ha/h, working field efficiency of 95%, fuel consumption of less than 15 l/ha and weight was of about 10 kg.

Baneh *et al.,* (2012) designed a cutting head for a portable brush cutter for harvesting rice crop. The cutting head consisted of a circular saw blade with a 24 cm diameter and 2 mm thickness. The designed blade had 136 teeth with 0° rake angle, 30° clearance angle and 6 mm pitch. A simple windrowing system was made from aluminium sheet. The results showed that the maximum power consumption was about 1.132 kW. The results also showed that field capacity of machine was 4.20 times greater than the manual harvesting and rice losses of the portable reaper were lower than the manual harvesting.

Gajakos *et al.,* (2013) carried out the evaluation of self-propelled vertical conveyor reaper for harvesting of soybean crop. The average effective field capacity of the self-propelled vertical conveyor reaper was found to be 0.255 ha/h and field efficiency was 88.59%. The average harvesting losses in mechanical harvesting and manual harvesting were found to be 5.68 and 4.73%, respectively. The fuel consumption of the self-propelled vertical conveyor reaper was 0.728 l/h and 2.84 l/ha. The cost of operation of self-propelled vertical conveyor reaper and manual harvesting were Rs 775.64 /ha and Rs 1264 /ha, respectively. Adisa (2013) evaluated the field losses of grain stripping harvester for paddy crop. The harvesting losses estimated for paddy harvesting with a grain stripping harvester gave overall 13.5% loss of the total yield at the best settings. At 220 mm rotor height, 560 rpm rotor speed and 4.2 km/h forward speed combination settings, minimum shattering loss was 7.3 %, stubble loss was 6.0 % and lodging loss was 3.6% of the yield. At 270.0 mm rotor height, 670 rpm rotor speed and 3.0 km/h forward speed combination setting minimum shattering loss was 5.5%, stubble was 4.9% and lodging loss was 3.1% of the total yield.

Karahle *et al.,* (2013) evaluated the performance of self-propelled reaper binder for harvesting of wheat and paddy crops. The average field capacity of the reaper binder was 0.359 ha/h., the field efficiency was 91.76% and average forward speed was 3.22 km/h. The average shattering loss was found 0.23% only. The average cost of operations was found to be Rs 1725.76 /ha.

Mehetre *et al.,* (2014) evaluated the performance of a self-propelled vertical conveyor reaper. The vertical conveyor reaper was found to be suitable for reaping the crops up to 55 to 60 cm crop height.

The result indicated an average effective field capacity of 0.17 ha/h at an average forward speed of 1.7 km/h with 60% efficiency. Operating cost of the machine was worked out to be Rs.115.27/h.

Murumkar *et al.,* (2014) conducted study on mechanized harvesting by a self-propelled vertical conveyor reaper for minimizing the cost of harvesting of paddy crop. The actual field capacity of the reaper was found to be 0.29 ha/h with a field efficiency of 70% at an average operating speed of 3.00 km/h. and the fuel consumption was 0.8 l/h. the cost of mechanical harvesting was Rs 690 /ha as compared to Rs 2500 /ha as in case of traditional method i.e. manual harvesting using local sickle.

Aung *et al.,* (2014) evaluated the performance of a power reaper and compared it with manual harvesting by sickle. The results indicated that the actual field capacity of the reaper was 0.24 ha/h as compared to 0.05 ha/h for manual harvesting. The actual cutting width of the reaper was 1.2 m. the labor requirements for reaper and manual harvesting were 4 and 128 man-h/ha, respectively. The cutting cost of power reaper was 67% less as compared with manual harvesting. The grain loss was less than 0.5%.

Laukik *et al.,* (2014) fabricated compact harvester for cutting up to two rows of soybean plant. It had cutting blades, which cut the crop in a scissoring type of motion with diesel engine of 3 hp, power from engine, was provided through pulley and gear box arrangement to the cutter.

A collecting mechanism was provided for the collection of crops at one side after cutting. After testing, it was found that the cost of harvesting was considerably less as compare to manual harvesting. Dange *et al.,* (2015) conducted a study on the harvesting of wheat and paddy crop by using a self-propelled vertical conveyor reaper. The results showed that the actual field capacity for paddy crop harvesting was 0.276 ha/h. whereas for wheat crop it was found to be 0.311 ha/h with a fuel consumption of 6.12 and 5.29 l/ha respectively. The cost of mechanical harvesting with the reaper was found 47.11% less for paddy crop and 44.4% for wheat crop as compared to the manual harvesting.

Shalini *et al.,* (2015) fabricated a self-propelled crop reaper which cuts up to two rows of soybean plant. The components of the machine comprised of a diesel engine of 3.5 hp, belt drive, pulley, collecting mechanism and a cutter bar. The power from the engine was provided to the cutter through pulley and belt arrangement and as compared with manual harvesting 20% of labors were required. Patel *et al.,* (2018) evaluated the performance of self-propelled reaper binder for harvesting of wheat crop. The effective field capacity of the reaper binder was found as 0.17 ha/h with a field efficiency of 78.49% at an average operating speed of 2.55 km/h. The fuel consumption was observed as 1.12 l/ha. The harvesting cost and losses were Rs. 3235.11/ha and 25.42 kg/ha respectively. Vignesh and Kumar (2018) designed and fabricated an agricultural reaper. The modified automatic operated reaper work continuously and gave more efficiency than the machine before its modification. The results showed that the field efficiency was more than 66% and it increased from 59% due to these modifications.

Materials and Methods

The developed portable harvester was evaluated on wheat crop at Advanced Centre for Rainfed Agriculture (ACRA), Dhiansar, SKUAST-J, and Farmer's field, Chatha. The harvesting of wheat crop was done both manually (with sickle) and mechanically (with portable crop harvester). The operational time was recorded for both of mechanical and manual harvesting.

Measurement of Crop Parameters

The crop parameters such as row to row spacing, stem diameter, crop height, height of cut, plant population, no. of tillers per plant, pre-harvest losses, post-harvest losses, grain weight and grain moisture content were measured/calculated as below:

Row to row spacing

The row to row spacing was measured by measuring the distance between two rows of the crop with the help of measuring tape.

Stem diameter

The stem diameter of plant was measured by measuring diameter of five randomly selected plants in the field with the help of Vernier Caliper having a least count of 0.1 mm.

Crop height

The height of the crop was taken from its base at ground level to its top when the plant is straightened; expressed in centimeters and the plant length was measured with the help of measuring 100 cm wooden scale.

Height of cut

To determine the height of cut, stubble height from the ground of five randomly selected plants were measured with the help of a measuring 100 cm wooden scale.

Plant population

The number of plant present per meter square is known as plant population and is expressed as no/m^2. The number of plant present in an area of one square meter were counted in the field with the help of a square frame.

Number of tillers per plant

The number of tillers per plant were recorded from randomly selected plants in number in each treatment manually and their average was calculated.

Measurement of performance parameters

Post-harvest losses

In order to determine the post harvesting losses, the frame of size (1m × 1m) was placed on the ground in front of the machine within the harvested area after backing the length of the machine. The grains found inside the frame were collected and counted. Similarly, grains were also collected from other places of the experimental plot.

The grains found from all plots were averaged and the pre-harvest loss subtracted to arrive at post-harvest losses.

$$\text{Post-harvest losses}(\%) = \frac{\text{Post-harvest grain losses (kg/ha)}}{\text{Total grain(kg/ha)}} \times 100$$

Actual field capacity

Actual field capacity was measured based on area covered and actual time, including turning loss time. It was determined using the following formula (Hunt, 1995):

$$\text{Actual field capacity (ha/h)} = \frac{A}{T_t}$$

Where,

A = Area covered, ha

T_t = Total operating time, h

Speed of travel (forward speed)

The speed of travel was calculated to determine other performance characteristics like field capacity and field efficiency.

During the field trial of portable crop harvester, speed of operation was measured by recording the time required to cover 10 meter distance by using a stop watch. The speed of operation of harvester was calculated by using following formula.

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

Theoretical field capacity

Theoretical field capacity was measured based on the forward speed and the cutting width of reaper. It was determined using the following formula (Hunt, 1995):

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

Where,

W = Effective width of operation, m

S = Speed of operation, km/h.

Field efficiency

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):

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

Cost of Operation

The cost of operation of the harvester in term of Rs/h and Rs/ha was determined based on fixed cost (Straight line method) and variable cost. Annual use of the developed harvester was considered as 150 hours. The following formulae were used for cost calculation of the harvester.

Fixed costs

Fixed costs includes depreciation cost, interest on the machinery investment, taxes, insurance and shelter, and it is a function of purchase price, rate of interest and useful life of the reapers. A straight-line method was used for calculation of depreciation cost (Hunt, 1995).

$$\text{Annual Depreciation (D)} = \frac{P-S}{L \times H}$$

Where,

D = Depreciation cost, average per year,

P = Purchase price of the machine (Rs.)

S = Salvage value of the machine (Rs.)

L = Useful life of the machine in years

H = Working hours per year, hours

Interest is a cost on the investment of agricultural machinery and was calculated by:

$$\text{Interest on investment (I)} = \frac{P+S}{2} \times \frac{I}{H}$$

Where,

I = Interest on capital Rs./h,

P = Purchase price of the machine (Rs.)

S = Salvage value of the machine (Rs.)

i = Interest rate in fraction

H = Working hours per year, hours

Variable cost

Fuel consumption (l/ha)

The separate fuel container with inverted scale was used, which was attached with fuel delivery and return pipe. The amount of fuel consumption was measured directly.

$$\text{Fuel Consumption (l/ha)} = \frac{\text{Fuel consumption (L)}}{\text{Area covered (ha)}}$$

Oil

The cost of engine oils and lubricants was estimated as 2 % of fuel consumption cost.

Repair and maintenance

It was taken as 6% of purchase price.

Wages and labour charges

The cost of labour was estimated taking the prevailing rate of Rs. 43.75/h.

Results and Discussion

Crop Parameters

The crop condition were studied and different relevant parameters calculated/measured in terms of row to row spacing, crop height, plant population, crop moisture content. The mean values the different parameters for wheat crop are given in Table 1 and 2.

Row to row spacing

The sowing of wheat crop in ACRA Dhiansar, SKUAST-J was done in line manually. Thus, row to row spacing obtained 22.5 cm. and the sowing of wheat crop in Farmer's Field, Chatha was done with broadcasting method.

Crop height

The overall average value of crop height of randomly selected plants in the field was found to be 94.97 and 80.93 cm for PBW-175 and VL-907 variety of wheat crop, respectively.

Stubble height

The overall average stubble height of randomly selected plants in the field was found to be 8.6 and 8.4 cm for wheat crop at ACRA Dhiansar, SKUAST-J and Farmer's Field, Chatha, respectively.

Plant population

The overall average value of plant population of randomly selected plants in the field was found to be 163.75and 154.80for PBW-175 and VL-907 variety of wheat crop, respectively

Number of tiller per plant

The average number of tiller/plant in all treatments was 5.2 for PBW– 175 variety of wheat crop and the average number of tiller/plant in all treatments was 4.6 for VL-907 variety of wheat crop.

Pre-harvest losses

The pre-harvest losses of wheat crop yield at ACRA Dhiansar SKUAST-J and Famer's Field, Chatha was found 0.65 and 0.55 %, respectively.

Grain weight

The average weight of thousand grains was found to be 42.3g in all treatments for PBW-175 variety of wheat crop and 38.9g for VL-907 variety of wheat crop, respectively

Crop moisture content

The moisture content of the wheat crop at ACRA Dhiansar, SKUAST-J and Farmer's Field, Chatha was found to be 12.7 and 12.4 %, respectively.

Performance Evaluation of the Developed prototype

In order to evaluate the developed prototype for wheat crop experiments were carried out at Advanced Centre for Rainfed Agriculture (ACRA), Dhiansar, SKUAST-J and Farmer's Field, Chatha.

The overall performance of the portable harvester was evaluated on the basis of harvesting losses (post-harvest losses), actual field capacity and field efficiency and was also compared with the manual method of harvesting i.e. by sickle. The comparison was made in terms of harvesting losses, actual field capacity, field efficiency, labor required and operational cost.

Harvesting losses

The permissible harvesting losses with the value of 1.11 and 1.15% were found in the operation of the developed prototype at both locations and the manual harvesting resulted into the minimum harvesting losses of 0.66 and 0.84% at both locations.

Actual field capacity

The developed prototype resulted into the maximum actual field capacity with a value of 0.039 and 0.037 ha/h and that with manual harvesting found to be 0.007 and 0.007ha/h at both locations under study. The actual field capacity of the developed prototype was five times more than that of the manual harvesting.

Table.1 Mean values of different crop parameters in ACRA Dhiansar, SKUAST-J

S.No	Crop parameters	Value		
		Minimum	**Maximum**	**Average**
1.	Crop height, (cm)	88	108	**94.97**
2.	Plant population, (no./m^2)	157	171	**163.75**
3.	Row spacing, (cm)	22.50	22.50	**22.50**
4.	Condition of crop	**Erect**		

Table.2 Mean values of different crop parameters in Farmer's Field, Chatha

S.No	Crop parameters	Value		
		Minimum	**Maximum**	**Average**
1.	Crop height, (cm)	70	94	**80.93**
2.	Plant population, (no./m^2)	147	162	**154.80**
3.	Row spacing, (cm)	-	-	-
4.	Condition of crop	**Erect**		

Fig.1 Harvested by portable crop harvester

Fig.2 Harvesting losses (%) at ACRA Dhiansar, SKUAST-J and Farmer's Field, Chatha

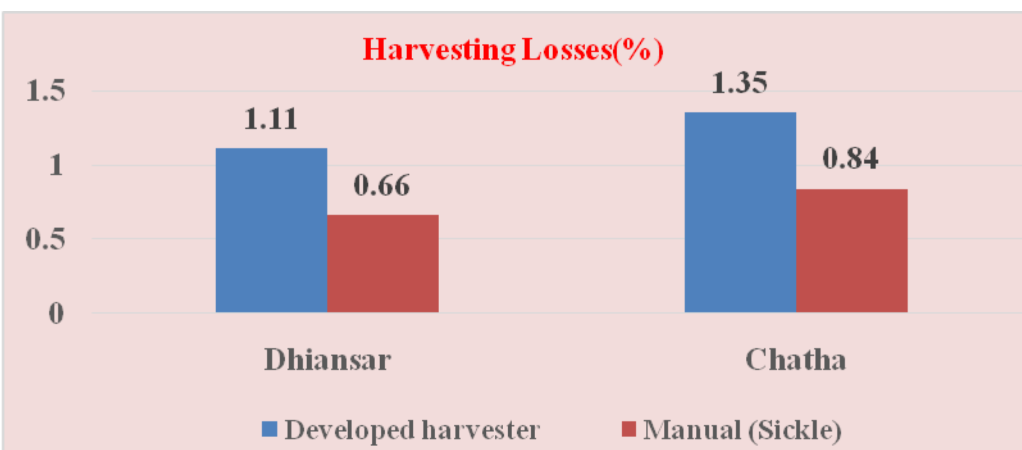


Fig.3 Actual field capacity (ha/h) at ACRA, Dhiansar, SKUAST-J and Farmers Field Chatha

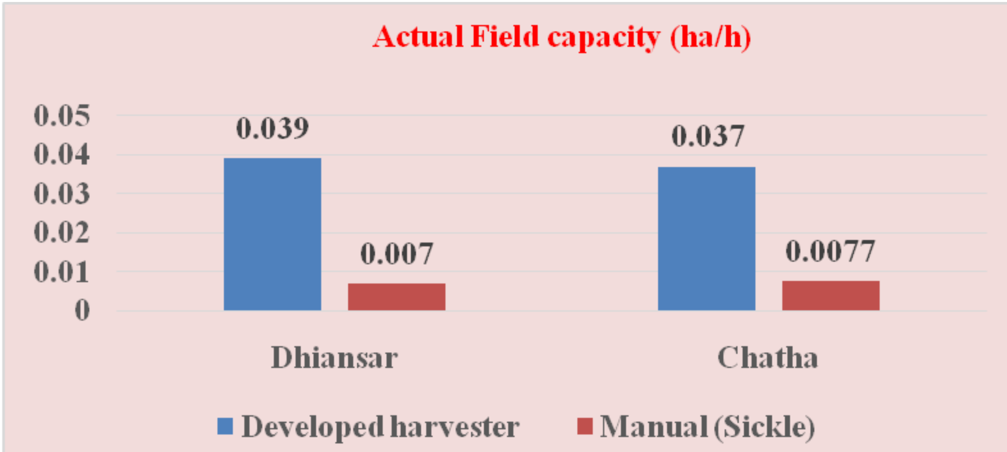


Fig.4 Field efficiency (%) at ACRA, Dhiansar, SKUAST-J and Farmers Field Chatha

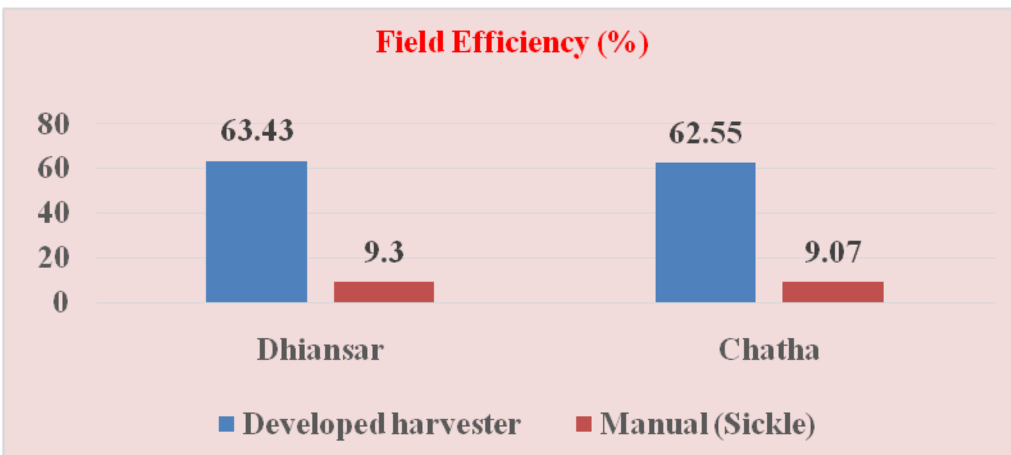


Fig.5 Labour requirement (man-h/ha) at ACRA, Dhiansar, SKUAST-J and Farmers Field Chatha

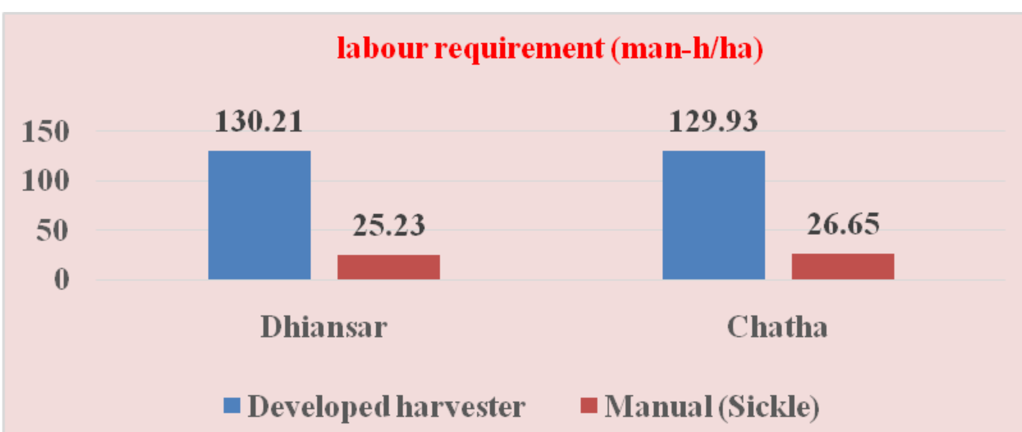
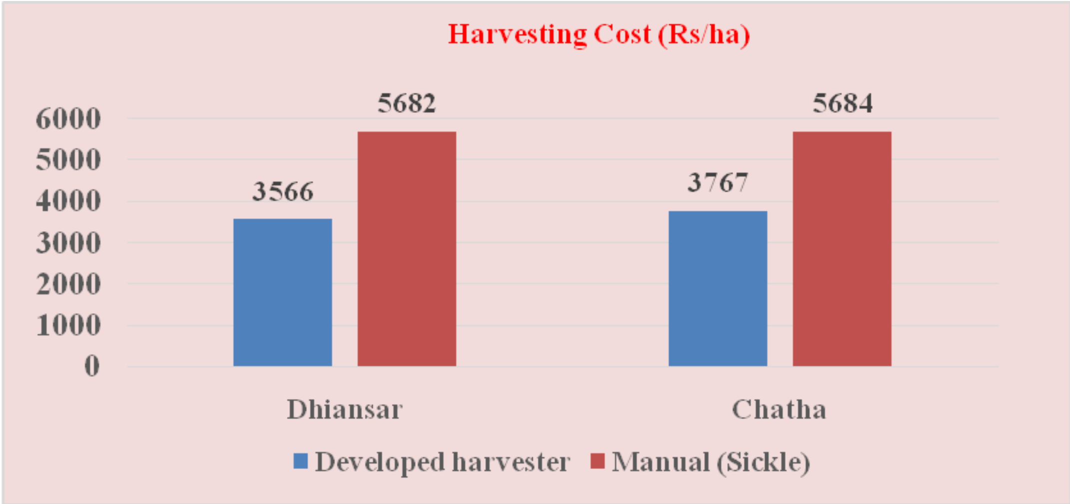


Fig.6 Cost of operation (Rs/ha) at ACRA, Dhiansar, SKUAST-J and Farmers Field Chatha



Field efficiency

The developed prototype resulted into the maximum field efficiency with a value of 63.43 and 62.55% and that of manual harvesting was found to be 9.30 and 9.07% at both locations under study.

Labour requirement

The labour requirement in terms of man-h/ha was calculated for the harvesting of the wheat crop. The labour requirement for harvesting by sickle was found to be 130.21 and 129.93 man-h/ha at both locations and for the developed prototype to be 25.23 and 26.65man-h/ha at both locations, respectively.

Cost of operation

The manual harvesting by sickle resulted into the maximum cost of operation with a value of Rs 5682/ha and Rs 5684/ha at both locations. The minimum cost of Rs 3566/ha and Rs 3767/ha at both location for the wheat crop harvesting was obtained by developed prototype. Therefore, the net saving of Rs 2116/ha and Rs 1917/ha at both location was recorded with the developed prototype over the manual harvesting by sickle. The performance of the developed harvester was evaluated in the field for wheat crop at Advanced Centre for Rainfed Agriculture (ACRA), Dhiansar, SKUAST-J, and Farmer's Field, Chatha. The performance evaluation of the developed portable crop harvester was carried in terms of post-harvest losses, actual field capacity and field efficiency and was also compared with the manual method of harvesting i.e. by sickle. From the study undertaken following conclusions may be drawn:

The developed portable harvester worked satisfactorily with an average value of 1.11 and 1.35% for post-harvesting losses, actual field capacity of 0.039 and 0.037 ha/h and field efficiency of 63.43 and 62.55% at both locations, respectively.

The permissible harvesting losses with the value of 1.11 and 1.35 % were found in the developed portable harvester followed by the manual harvesting 0.66 and 0.84% at both locations, respectively.

The labour requirements were found to be 130.21 and 129.93 man-h/ha for sickle and 25.23 and 26.65 man-h/ha for the developed portable harvester at both locations, respectively. The labour requirement of sickle was almost five times more as compared to the developed portable harvester.

The cost of harvesting of wheat was found to be maximum for manual harvesting by sickle at Rs 5682 and 5684/ha, whereas the lowest cost was recorded with the developed portable harvester at Rs 3566 and 3767/ha at both locations, respectively. The net saving of Rs 2116 and Rs 1917/ha at both locations was recorded with the developed portable harvester over traditional manual harvesting by sickle.

The harvesting cost of developed portable harvester was reduced by about 37 and 34%, as compared to manual harvesting method at both locations, respectively.

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