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RESEARCH ARTICLE

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Performance Evaluation of Vertical Cutting Reaper Harvester for Barley

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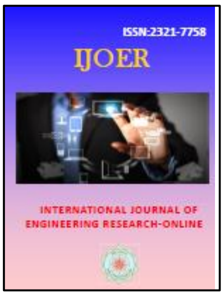

ABSTRACT

Mechanized agriculture is the process of using agricultural machinery to mechanize the work of agriculture, greatly increasing farm worker productivity. Harvesting of grain refers to the activities performed to obtain the cereal kernels of the plant for grain, or the entire plant for forage and/or silage uses. This study was planned to undertake with the objectives of evaluating the performance of vertical reaper harvester on Barley using efficiency indicators, to reduce loss of grain by unseasonal rain by earlier harvesting (soon grain get matured) and to adapt harvesting technologies with small scale farmers and increase farm workers' productivity by saving labor and time. Evaluation was done on vertical reaper harvester using conventional harvester (Sickle) which farmers use as control with completely randomized experimental design. Each plot had an area of 9m by 20m (180m^2). It required three fewer labors than the conventional one to harvest selected plot. The harvester consumed 9.4l/ha on average and it could harvest 0.18 hectares within an hour. Percentage of harvest loss was 0.1%. Average field capacity was found as 79.24%. Hence, Vertical reaper harvester was feasible and economical compared to conventional harvester in terms of time and labour requirement.

Keywords:-Barley, Vertical Reaper Harvester, Harvesting time, Harvesting efficiency

1. Background and Justification

Barley (*Hordeum Vulgare L.*), is one of the most important cereal crops in the world. It is widely grown fourth cereal and among top ten crop plants in the world. It is very important cereal in terms of 132 million tons production, 55 million ha acreage and 2.4 t/ha yields in the world. Barley grain is also very important source for malt and food for human (Taner., *et al*).

Manual labour takes time and is not effecti ve as they can work for 3-4 hours at a stretch (Laukik et al., 2014). It is a cereal grain in the grass family, is used as a livestock feed and in foods (e.g. cereals and soups) for human consumption. It is also converted into malt for brewing, distilling, and various other products (e.g. malted milk). Some growers use smooth-awn or awn less varieties in hay production (Anon, 2012).

Mechanized agriculture is the process of using agricultural machinery to mechanize the work of agriculture, greatly increasing farm worker productivity. In modern times, powered machinery has replaced many jobs formerly carried out by manual labour or by working animals such as oxen, horses and mules. Mechanization involves the use of an intermediate device between the power source and the work. This intermediate device usually transforms motion, such as rotary to linear, or provides some sort of mechanical advantage, such as speed increase or decrease or leverage. Current mechanized agriculture includes the use of tractors, trucks, combine harvesters, airplanes (crop dusters), helicopters, and other vehicles. Modern farms even sometimes use computers in conjunction with satellite imagery and GPS guidance to increase yields (Chavan *et al.*, 2015).

Labour scarcity during peak period of harvesting leads to delay in harvesting and field grain losses. Also high labour wages during peak period adds extra cost in total cost of cultivation. Mechanized harvesting is an alternative solution to tackle this problem. Mechanization has had a major impact on the demand and supply for farm labor; the profitability of farming; and the change in the rural landscape, including rural communities. Mechanization can displace or substitute for workers in cases of labor shortages. Farm mechanization will also result in lesser cost of operation (Schmitz and Moss, 2015).

Harvesting of grain refers to the activities performed to obtain the cereal kernels of the plant for grain, or the entire plant for forage and/or silage uses. These activities are accomplished by machines that cut, thresh, screen, clean, bind, pick, and shell the crops in the field. Harvesting also includes loading harvested crops into trucks and transporting crops in the grain field. Harvesting is an important step affecting the output and the agricultural-goods directly. It lasts for a short time but needs much labor and is hard work**.**

Harvesting is an important step affecting the output and the agricultural-goods directly. It lasts for a short time but needs much labor and is hard work**.** Harvesting mechanization for main crops is a large and complex field of science and technology. Hence, this study was planned to undertake with the objectives of evaluating the performance Vertical Reaper Harvester on Barley using efficiency indicators, to reduce loss of grain by unseasonal rain by earlier harvesting (soon grain get matured) and to adapt harvesting technologies with small and medium scale farmers. It was also aimed to increase farm workers productivity by saving time and labor through introducing machine and further more to mechanize target group farming system.

2. Literature Review

Some of the earliest mechanical innovations in agriculture involved the replacement of draft animals with the steam engine power, which was replaced by the internal combustion engine. Today, agricultural mechanization includes information technologies such as those used in precision agriculture(Schmitz and Moss, 2015). Although the use of precision agriculture technology offers significant savings in labor and other costs within a reasonably short payback period, the rate of adoption by farmers has been somewhat uneven both geographically and temporally (Swinton and Lowenberg-deBoer, 2001).

In foreign countries, wider tests of stripping crop ears were started in the nineties of the 20th century, and nowadays various stripping devices are produced and widely implemented in numerous countries. The UK Company Shelburne Reynolds Engineering Ltd is the leader in this field. Investigations are carried out in Germany, Italy, Canada, Austria, Russia, Belarus, Latvia, Ukraine and other countries as well. In scientific literature, a lot of articles have been published on stripping issues. Beginning from 1987 (Klinner, 1987), the investigations have been carried and are continued at present (Vlasenko, 2004).

The timing of harvest is similar for both hulled and hulless varieties. However, additional care must be taken in harvesting hulless barley to minimize damage to the unprotected grain. Barley is typically harvested when the grain is at 13 to 15 percent moisture. When harvested at a higher moisture content, the grain must be quickly dried to prevent sprouting and spoilage (Anon, 2012).

3. Materials and Methods

3.1. *Materials*

Materials used for conducting this study was vertical reaper harvester Model TNS-4S-120, Sickle (conventional harvester), moisture meter (Dramniski, Ploland), Soil Penetrometer, Dry oven, meter, electronic and spring balance, Canvas sheet, plastic bags (Sample bags), sack, stop watch, fuel and data sheet.

3.2. *Methods*

The study was conducted at Bokoji district located in Limuna Bilbilo woreda of Arsi zone, Oromia Regional State, Ethiopia, where Barley is produced dominantly.

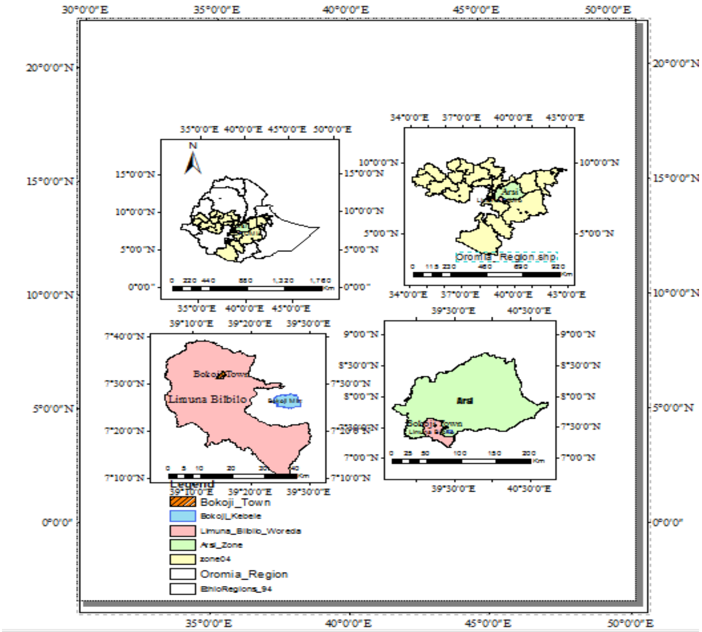

Figure 1 Location Map of Study area

Evaluation was done on vertical reaper harvester using conventional harvester (Sickle) which farmers as control. Each plot had an area of 180m^2. On farm trials and data collections were conducted for each plot. Independent variables were plant population per plot, soil Penetrometer resistance, grain moisture content, operating speed, lodging angle and number of Tiller. Dependent variables where field capacity, field efficiency, loss before harvest, loss after harvest, operating time, fuel consumption, conveying loss per width of cut.

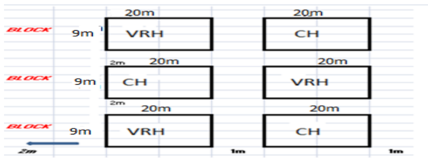

Figure 2:- Experimental Field layout

Note:-VRH-Vertical Reaper Harvester, CH-Conventional Harvester

3.2.1. Working principles

Vertical reaper harvester is self-propelled machine and power transmission to reaper is pulley and belt system. Its cutting mechanism is vertical cutting. The operator is walking behind the machine as shown on figure 2.

Table 1- Specification of Vertical Reaper Harvester vertical Reaper Harvester Specifications

No.	Model	TNS-4S-120
1	Overall dimensions: (LxWxH)	2390x1470x900mm
2	Cutting width	120cm
3	Working capacity	3-4hr/ha(1.2-1.6hr/acre)
4	Engine type	Petro-kerosene, air-cooled, 4-stroke, single cylinder
5	Optional engine	Gasoline/petro-kerosene/diesel oil
6	Displacement	163cc
7	Maximum power output	(5.5HP) 4.0kw/3600rpm
8	Starting system	Reclil/electric
9	Fuel capacity	3.6Liters
10	Air Cleaner	Semi-dry, oil bath, dual
11	Packing size(1650x1410x600)	1650x1410x600
12	N.W/G.W:	125/165kgs

Before the start of the test, the reaper harvesters had undergone running-in period wherein various adjustments of the reaper was made according to the recommendation of the manufacturers. (No other adjustments shall be permitted while the test is on-going). Field performance test was carried out to obtain actual data on machine performance, operating accuracy, work quality and adaptability to varied crops and field conditions.

3.2.2. Performance evaluation approach and data collection

Data collected from the study were; operating speed for harvesting machine (m/s), Fuel consumption for harvesting machine (ml), operating time(minutes), Header loss (pre-harvest loss), Conveying loss, Potential yield, Plant population, Soil type,

For both treatments Soil moisture content was done by dry oven. Grain moisture content was done by moisture meter (Dramniski, Ploland). Soil penetrometer resistance was done by Cone penetrometer. Potential yield was done for 1m by 1m size; whereas final yield was done for 9m by 20m. Operating speed for harvesting machine was computed from the ratio of total distance covered to total time taken.

Operating speed was measured from the time required for the machine to travel the distance (20m) between the assumed line connecting two poles on opposite sides AC and BD. Fuel consumption was measured by filling fuel tank and refilling after each test trial using graduated cylinder. The amount of refuelling was the fuel consumption for the test. Total operating time was measured once the machine starts to reap up to the time it cuts the last stalk.

Header loss was determined before the test run, five 1m x 1m area taken at random within the test plot and the grains detached from the panicle within the area collected weighed and recorded as pre-harvest loss. That was done for five samples collected after the test run was manually threshed, cleaned and weighed. Conveying loss was determined from canvass spread for a length of 2mx1m on a place where cut stalks were expected to fall. Detached grains from the panicle was collected, labeled and taken to the laboratory. For this five sets of samples were taken. Total loss was computed by summing pre-harvest loss (W_p), conveying loss (W_c), and uncut loss (W_u)

$$W_t = W_p+W_c+W_u \quad \ldots\ldots(1)$$

Potential yield of the area was done by manually threshing grains from the cut stalk from each sample separately. Potential yield was done by randomly selected three 1mx1m area within the test plot and manually harvest the panicles. It was cleaned remove the impurities and other foreign matters. The clean grain shall be weighed and recorded. Calculate the average potential yield per square meter of the three samples.

Effective field capacity was measured by the actual area covered by the reaper-binder, based on its total time consumed and its width. It was determined by the following relationship:

$$\text{Effective Field Capacity(ha/h)} = \frac{\text{Total Area Covered (ha)}}{\text{Total Time Taken (h)}} \quad \ldots\ldots(2)$$

Effective field capacity was measured by the actual area covered by the reaper-binder, based on its total time consumed and its width. Effective field capacity was determined by the following relationship: Effective field capacity : Effective field capacity was measured by the actual area covered by the reaper-binder, based on its total time consumed and its width. Effective field capacity was determined by the following relationship:

$$\text{Theoretical Field Capacity (ha/h)} = \frac{\text{Width (m) x Speed (km/h)}}{10} \quad \ldots\ldots(3)$$

Theoretical field capacity is the rate of field coverage of the machine, based on 100 per cent of time at the rated speed and covering 100 per cent of its rated width. Width taken was 1.2m which was given on specification of the machine. It capacity was determined by using the following relationship:

$$\text{Field Efficiency (\%)} = \frac{\text{Effective Field Capacity (ha/h)}}{\text{Theoretical Field Capacity(h a/h)}} x100 \quad \ldots\ldots(4)$$

Field efficiency was determined by the ratio of effective field capacity to theoretical field capacity. It was determined by the following formula:

4. Result and Discussion

From the study conducted on harvesting Barley, test parameters were harvesting duration per plot, labor requirement, conveying loss, potential yield straw, net yield were collected as shown in table 2. The labour requirement was found to be 2 men per plot for Vertical reaper Harvester compared to 5 men per plot in manual harvesting, collecting and bundling of the crop. Thus, it saved 3 men per plot. The study showed that Reaper harvester was more time and labor saving as compared with the control (conventional) harvester. Average time required to cover 20m for vertical reaper harvester was 0.52minutes where as it was 9.58 minutes for conventional harvester which showed labor and time required for machine was much more fewer than conventional harvester. Fuel consumption was 146.7 ml/plot or 9.2l/ha. Effective cut width was 1.13m which was less by 0.06% from that of manufacturer (1.2m).

Table 2- Result of Required Parameters for Vertical Reaper Harvester

Block	Treatment	plot size (mxm)	Average before harvest loss (gm)	Average lodging angle	Average conveying loss(gm)/width of cut by 2m	Number of labor	Average time(min) at 20m distance	Fuel consumption (ml/plot)	Total operating time(min)	After harvest loss(gm)/m2	Width of cut(cm)
1	VRH	180	5.3	23.8	0.9	2	0.57	130	5.03	22.4	102.7
	CH	180	1.6	19.1	8.1	5		0	27.34	32	91.7x5
2	VRH	180	1.3	22.2	3.3	2	0.6	190	5.45	33.2	120
	CH	180	4.8	12.7	41.6	5		0	30.35	49.6	114.7x5
3	VRH	180	3.6	22	1.5	2	0.52	120	5.44	23.6	113
	CH	180	5.6	25.7	23.6	5		0	21.57	32.4	136.7x5

a. Harvesting b. Turning

Figure 3. On Farm Test of Vertical Reaper Harvester on Barley Crop

Net yield was 117 kg/plot or 73 quintals/ha. Uncut, before harvest and conveying losses were 0, 3.4 and 4.5kg/ha respectively. Total loss was 7.9kg/ha. Percentage of harvest loss was 0.1%, which was negligible. Cutting width was 1.12m whereas cutting height was 13.8cm for reaper harvester and 36cm for conventional one. From the study mean field efficiency of the harvester machine was 79.34%.

Table 3. Computation of Field Efficiency for Vertical Reaper Harvester

Block	Treatment	plot size (m^2)	Speed (km/h)	Effective Field Capacity (m^2/min)	Effective Field Capacity (ha/h)	Theoretical Field Capacity (ha/h)	Field Efficiency (%)
1	VRH	180	2.11	35.79	0.21	0.25	84.99
	CH	180		6.58	0.04	0.00	
2	VRH	180	2.00	33.03	0.20	0.24	82.57
	CH	180		5.93	0.04	0.00	
3	VRH	180	2.31	33.09	0.20	0.28	71.69
	CH	180		8.34	0.05	0.00	
Average	VRH	180	2.14	33.92	0.20	0.26	79.34
	CH	180		6.81	0.04	0.00	

5. Conclusion

Reapers are used for harvesting of crops mostly at ground level. From the study, the Vertical Reaper Harvester could be used successfully with a labour saving of 3 men per plot and reducing the drudgery of labors. Generally, it was concluded that vertical reaper harvester is much better than conventional one in aspect of labor and time saving. It also covers much more area with negligible loss to harvest within short time which reduces harvest loss due to rain which can occur during harvesting season. Since cutter speed is higher and lodging angle is appropriate and constant once adjusted it has minimum harvesting loss than conventional one.

Hence, machine harvesting was feasible and economical compared to traditional method in terms of time, labour requirement and money.

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