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Adaptation and Evaluation of Manual Hay Baller

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ABSTRACT

Baling of straw by pressing helps to feed animals with little or no wastage, conserve its nutrient for a long time, simplifies the transport and storage condition. Straw are considered among the most important materials in Ethiopia especially tef, wheat and barley straw. There are many types and models of powered and automatic baler imported in Ethiopia to assist baling facility. But those machines which are not affordable to small scale farmers due to high in cost and in another side in Ethiopia, the concept of high capacity baler could not make any impact owing to scattered and small areas of field. Therefore the manual hay baler machines was adapted and evaluated in those areas. The performance of the machine is evaluated in terms of density, mass, pressing rate and time required. Vertical hay baler has better performance in baling rate than the others manual hay balers.

Keywords: *Hay baler, Baling rate, Baling density, Baling time, Traditional.*

1. Introduction

Agriculture is the basis of Ethiopia's economy. In Ethiopia, the agricultural sector is a corner stone of the economic and social life of the people. The sector employs 80-85 percent of the population and contributes 40 percent to the total GDP (Aleme and Lemma, 2015). According to the livestock census of CSA, (2016/7), Oromia Region has about 24,144,361 million cattle, 9,866,172 million sheep, 8,129,784 million goats, 1,296,520 horses, 140,114 mules, 3,446,746 donkeys, 299,422 camels, 20,408,299 million poultry and 2,993,147 beehives constituting about 35.7 percent of the national livestock population. In Ethiopia, tef, barley and wheat are cultivated about 3.023, 1 and 1.7 million ha with a production of 5.3, 2.1 and 4.6 Million tons respectively, Where as in Oromia 1.4, 0.5 and 0.9 million ha with production of 2.6, 1.1 and 2.7 million tons respectively during 2017-18 (CSA, 2017/18). About 1 to 1.77 kg of paddy straw is produced per kg of grain harvested (Thirunavukkarasu, 2011) and thus, approximately 12 and 6 million tons of straw is estimated to be produced annually in Ethiopia and Oromia respectively.

The major barrier against the use of these bulky residues as feedstock was due to their collection, handling, transportation and storage. Baling is a process of reducing the material volume to achieve a defined package which facilitates handling and preserves material quality for future use. Hay making is traditional in most parts of Ethiopia, there is no wide practice of making or storing hay and straw in bale, rather most farmers and small-scale dairy holders store hay traditionally by making heap. However, the conventional method of haymaking has some drawbacks, such as feed loss; maintain low nutrient content, not convenient in transporting and storing. These drawbacks confirm that farmer's lacks knowledge about forage conservation, improvement of low quality feed and using of proper technology for haymaking and storing residue (Abu *et al.,* 2012).

Therefore, to alleviate problems associated with hay baling it was felt appropriate to adapt manual baler that can solve the problem raised above. Therefore this study was aimed with objectives of:

- ✓ *To adapt and evaluate the performance of manual hay balers under farmers' local conditions.*

2. Materials and Methods

In this particular paper, attempt has been made to evaluate manual hay balers. Based on extensive review, attempt on different existing manual hay baler of three models i.e. vertical screw type, horizontal metal body and horizontal wood body manual hay balers were selected. But, these balers are not used by farmers due to unavailability and poor awareness of farmers. All the three balers were evaluated on barley and wheat straw separately.

3. Experimental Site

After collected the balers, participant and farmers were selected from Arsi Zone (Hetosa, Digelu Tijo and Lemu Bilbilo districts) based on selection criteria. The zone astronomically lies between 6° 45‟ to 8° 58‟N and 38° 32 to 40° 50‟ E. It shares borderlines with west Arsi, Bale, west/Hararghe and east Shewa zones. It has 25 administrative districts including one especial district. Asela is the capital town of the zone. It is located at 175 km from Addis Ababa on Addis Ababa-Adama-Bale Robe main road (Tamrat, 2018. BOFED, 2011). The altitudinal ranges from 1500 to 4460 meters above sea level (Teklay, 2008).

3.1 Manual Hay Baler's Description

The Horizontal baler metal body piston type (figure 1) obtained from Selam technical and vocational school has a 282 x 51 x 72 cm (LxWxH) dimension whose body is made from sheet metals, angle iron, round bar, galvanized pipe, and U-channeled cross section metals. Its empty weight is 88 and 95 kg with and without wheel respectively.

Figure 1: Horizontal Baler (metal body)

The vertical hay baler screw type (Figure 2) obtained from Amio engineering whose parts are manufactured from sheet metals, angle iron, rectangular pipe, ball bearing and water pipe has the overall dimension of the machine (LxWxH) in centimeter is 74 x 86 x 186. Its weight is 94 and 87 kg with and without wheel respectively.

The Horizontal baler wood body piston type (Figure 3) Obtained from Bako Agricultural Engineering Research Center has a 200 x 52 x 100 cm (LxWxH) dimension whose body is made from hardwood

(eucalyptuses tree). Part other than the main body was made from angle iron, round bar, galvanized pipe. Its empty weight is 85.5 kg.

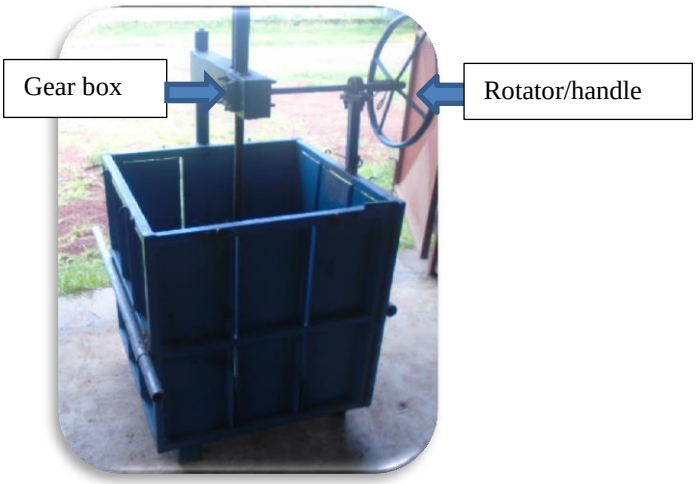

Figure 2: Vertical baler screw type

Figure 3: Horizontal baler (wood body)

3.2 Measuring Devices and Instruments

Baling time was measured by stopwatch. The length, width, and height of all bales were measured using tape meter. SALTER Model 235 6S – digital spring balance, made in England capacity of 50kg with 200g difference, was used to measure weights of bale.

4. Performance Evaluation

All manual hay balers were tested and evaluated for their capacity and also compared their advantage over the traditional hay making using their bale weight and area. Tests were conducted in three sites with three replications a total of nine replications using single hay bale with a single operator. The required area and weight of baled and hay were determined. Generally performance evaluation of all manual balers were made on the basis of the following parameters; density, mass, pressing rate and time required.

4.1 Statistical Analysis

Analysis was made using Statistix 8 statistical software. The treatment means that were different at 5% levels of significance were separated using LSDT. Level of significance (P) for these relations was obtained by F- test based on analysis of variance.

5. Result and Discussions

5.1 Performance of baler on wheat straw

As shown in figure 4. The average baling time, bale density and baling rate (output) of the vertical manual baler was 5.83 min per bale, 26.8 kg/m^3 and 87 kg/hr respectively on wheat straw. And for horizontal wood body and horizontal metal body balers were 12.8 and 6.23 min per bale, 29.72 and 39 kg/m^3, 39.6 and 75 kg/hr respectively. These results indicate that the vertical hay press performed better with less baling time and higher output and followed with horizontal metal body hay baler. But regarding to bale density horizontal metal body hay baler was better (Figure 4).

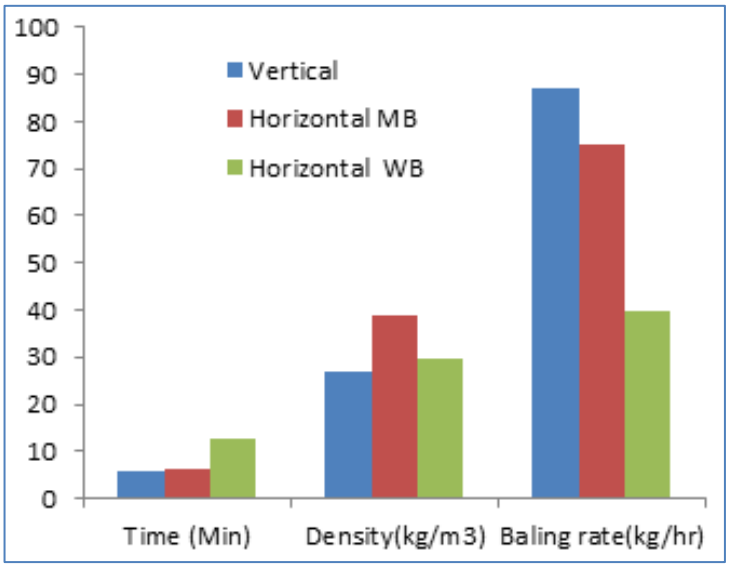

Figure 4: Mean performance parameters for vertical, horizontal MB and horizontal WB Manual hay baler on wheat straw

There were differences between the hay balers regarding baling time, pressing rate in favor of the vertical hay baler. The reason is that the vertical hay baler's piston unit is freely moved up and down with the use of ball bearing with help of beveled gear, so that the technique allows the operator to use his/her hand force to rotate the handle easily with minimum friction.

Therefore, this condition assists to reduce energy and facilitate easiness of operation. A similar relationship of bale density with compression force was reported by Abu *etal.* (2012). But the horizontal one requires more energy than the vertical one because of the pusher pad which slides over sheet metals and timber wood producing high frictional force and thus reducing operator's efficiency and speed. Regarding density in

favor of horizontal metal body hay baler this is due to compressed well and minimized the size when compared to others even if it needs high energy (Figure 4.).

Table 1: LSD All-Pairwise Comparisons Test of performance of all Balers on wheat straw

Parameters	TIME	MASS	DENSITY	PRESING RATE
HWB	12.783a	8.4667 a	30.063 b	0.6700 b
VB	5.833b	8.5667 a	26.923 b	1.4733 a
HMB	6.217b	7.8000 a	39.000 a	1.2533 a
CV %	8.98	8.58	12.17	10.39
Alpha = 0.05				

The same letter in column no significant difference at alpha 5%

As shown in table 1 there are no significant pairwise differences among the means of mass in all balers. Regarding to time, density and pressing rate there is significant difference at probability level of 5%. Pressing rate and time has no significance difference in Vertical and horizontal metal body balers. In vertical and horizontal wood body balers density is no significantly difference at probability level of 5%.

5.2 Performance of balers on barley straw

The average baling time, bale density and baling rate (output) of the vertical manual baler was 9.833 min per bale, 27.7 kg/m^3 and 148 kg/hr respectively on barley straw. Likewise similar parameters for horizontal wood body and horizontal metal body balers were 13.37 and 10.97 min per bale, 60.29 and 67.75 kg/m^3, 120 and 121.8 kg/hr respectively. These results indicate that the vertical hay press performed better with less baling time and higher output and followed with horizontal metal body hay baler. But regarding to bale density it is favor with horizontal metal body hay baler (Figure 5).

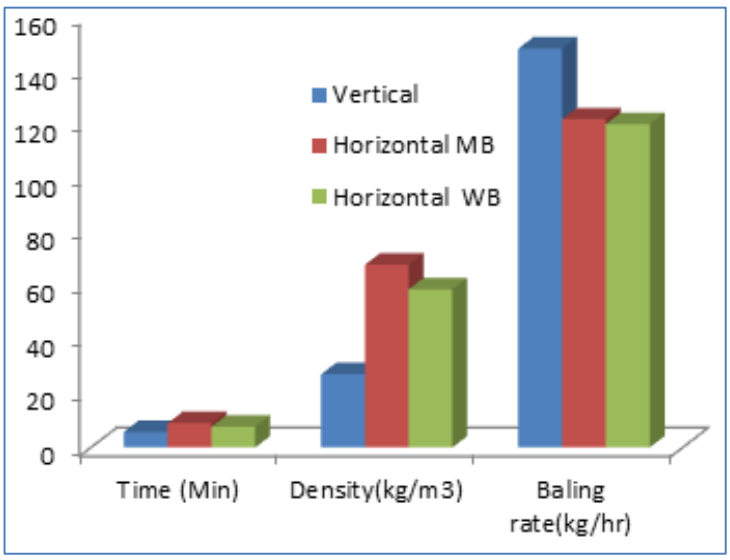

Figure 5: Mean performance parameters for vertical, horizontal MB and horizontal WB Manual hay baler on barley straw

Similar trend was obtained on the performance of all hay manual balers on barley straw as wheat straw. As shown in figure 5 baling time, pressing rate in favor of the vertical hay baler. Regarding to density in favors of horizontal metal body baler. Generally all manual hay balers show better result on barley straw than wheat straw. This may be barley straw pressed easily than wheat straw but it takes higher time per bale.

Table 2: LSD All-Pairwise Comparisons Test of performance of all Balers on Barley straw

Parameters	TIME	MASS	DENSITY	PRESING RATE
HWB	13.367 b	14.500 a	60.293 a	2.0350 a
VB	9.833 a	14.233 a	27.100 b	2.4800 b
HMB	10.967 a	13.467 a	67.747 a	2.0300 a
CV %	11.11	10.18	11.00	8.44
Alpha = 0.05				

The same letter in column no significant difference at alpha 5%

As shown in table 2 there are no significant pairwise differences among the means of mass in all balers on barley straw. Regarding to baling time, density and pressing rate there is significant difference among baler to baler at probability level of 5%. In Pressing rate and density have no significance difference in both horizontal metal and wood body balers. But the vertical has significance with other balers in density and pressing rate. Whereas vertical and horizontal metal body have no significance difference with time at probability level of 5%.

6. Conclusion

Based on the performance evaluation made and results obtained, the following conclusions can be drawn:

- ✓ Vertical hay baler has better performance in baling rate than the others manual hay balers
- ✓ Regarding to density it favors to horizontal metal body hay baler
- ✓ All manual hay balers have better result on barley straw than wheat straw
- ✓ All manual have no significance difference on mass in both wheat and barley straw.

7. Recommendation

Based on the farmers comment and findings obtained, the following recommendation was made:

- ➢ Since all the balers were operated manually, so it was difficult address medium and large scale farmers hence an automatic or semi-automatic baler must be developed and used.

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