On Farm Evaluation and Demonstration of Different Models of Hay Presses

Abu Teffera[1], Solomon Tekeste[1] and Yihalem Denekew[2]
[1]Bahir Dar Agricultural Mechanization Research Center, P.O. Box 133, Bahir Dar
[2]Andassa Livestock Research Center, P.O. Box 27, Bahir Dar

Abstract
Hay is the oldest and most important conserved fodder. The main aim of haymaking is to store feed for later on-farm use. Traditional haymaking practice in Ethiopia has many problems; delayed or early harvesting, improper handling systems during harvesting, transportation, and storage stages are identified as main causes of feed loss. This project is therefore intended to evaluate and demonstrate manual hay presses so as to assist users in haymaking and baling practice. Two hay presses models; vertical and horizontal hay press, were manufactured in the center and after preliminary test was carried out, practical on field test was carried out at two trail sites. Besides, discussions were made with farmers and their opinions were recorded. The test result has shown that, the average pressing rate, bale density, and baling time of vertical hay press was 45.20kg hr^{-1}, 86.5kg m^{-3} and 14min per piece. Likewise similar parameters of the horizontal type were 36.9kg hr^{-1}, 72.27 kg m^{-3} and 18 min per piece respectively. It was observed that most of the respondent farmers preferred the vertical type press due to its lower energy requirement and better out put.

Introduction

Agriculture is the basis of Ethiopia's economy. The contribution of livestock and livestock products to this sector is significantly high, accounting for 40%, excluding the value of draft power, fuel, manure, and transportation (Winrock International, 1992). According to the livestock census of CSA (CSA, 2001), Amhara region has about 9.12 million cattle, 3.82 million sheep, 2.96 million goats, 1.67 million equines and 11.95 million poultry and constituting about 35 percent of the national livestock population.

Grazing lands are the main source of livelihood to many farmers and pastoralists providing year-round feed supporting livestock. As green plants availability is seasonally in most areas, the provision of feed for deficit seasons has always been a major concern in many livestock production systems.

Hay is the most important conserved fodder used for this purpose. However, it may require extra care during harvest, transport, storage, and use. Hay can be prepared at household level using simple machines and techniques. Many small-scale farmers in the region make hay and store crop residues to carry livestock through periods of feed shortage. Residues, straws and Stover of the main field crop are used as animals feed. Traditionally the hay harvested by sickle is spread or left on the ground for 2-3 days to sun dry and once dried

the hay is collected and stacked in loose heaps raised off the ground on a platform of stone to avoid soil contact and spoilage. Hay is transported from farm area to the storing place manually and to the market place with carts. Carts to be used for this purpose will temporarily be modified by extending frames to increase their base area and allow transport of a greater load of bulky material.

The main aim of haymaking is to store feed for later on-farm use, and hence it should be easy to transport and store. Particularly, baled hay assist to feed animals with little or no wastage. Pressing of hay helps to conserve it's nutrients for long time and simplifies the transport, storage and preparation of feed rations. Hay can be pressed in to bales of 200-300 kg m^{-3} density when its moisture content is between 18-30% and in to briquettes of up to 700 kg m^{-3} densities when the moisture content is between 10-12% (Bosoi, O.V, 1991).

Studies indicate that, small-scale dairy holders store hay and straw in bales. The average weight of a bale from natural pasture and crop residues is 15-20 and 8-15 kg, respectively. The price of a bale also varies depending on the season and the distance between the production area and the major livestock/demand/market areas. (Suttie. 2000). Haymaking is traditional in most parts of Ethiopia. Especially, in the Amhara region there is no wide practice of making or storing hay and straw in bale. Rather most framers and small-scale dairy holders store hay traditionally by making heap. The price of hay depends on the seasons. A cart of hay/straw costs up to 180 Birr during dry seasons and up to 260 Birr in summer at Bahir Dar town markets. In other hand, animal drawn cart can carried 400-2000kg at speed of 3-5 km/h for distance of 20 km. (Lawrence, 1993).

Under existing practice forage is usually available during the rainy season while it is in short supply during the dry seasons. Therefore, off-season requirements set up by preserving wet-season herbage and residues of crops. 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. Therefore, hay making techniques and equipment should be major area of concern.

In other hand, because of in-accessibility of modern breeding service and favorable market condition (on selling of fatten ox, milk and milk products), most of the farmers in the region are engaged in livestock raring activities as a source of additional income. As currently conducted studies indicate, today, strong village level milk marketing units that are owned by farmers milk marketing groups/co-operatives are established, all are successful and are operating profitably (Rangnekar and Thorpe, *2002).* Therefore, in order to be more competent in the market, farmers should know proper method of animal feed preparation techniques and available equipment for haymaking.

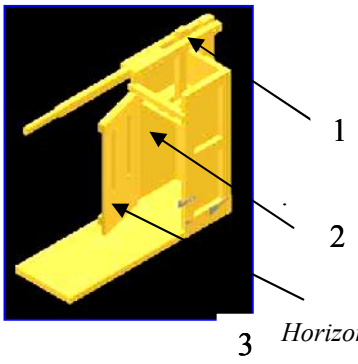
There are different types of haymaking machines in the market, out of which mechanical presser are the most important one. These machines have three level of operation: human powered (manual), animal powered, and mechanical powered. In this particular project attempt has been made to evaluate human powered once. Based on extensive review attempts on different hay press types two models, vertical and horizontal hay presses were selected. Both machines are hand-powered box baler, can be easily constructed from easily available materials. But, these presses are not used in the Region by farmers due to unavailability of presses in the market and poor awareness of farmers on the technologies. Hence, the objectives of this study was to verify the performance of improved hay presses under farmers' local conditions and increase farmers and extension/development workers awareness on the advantages of the technologies. It was also intended to render recommendations on the merits & demerits of the technologies.

Materials and Methods

Description of Hay Presses

Vertical hay press

The vertical hay press (Figure 1) parts are manufactured from hard wood (eucalyptuses tree) and sheet metals. It consists of wooden frame box that is laminated from the inside with 0.8mm sheet metal. It has wooden bottom floor and wooden plunger with arms laminated by 3mm sheet metal. The overall dimension of the machine (LXWXH) in centimeter is 154X54X145. Its weight is 88kg and its manufacturing cost was about 626 ETB.



Vertical hay press main parts

1. plunger with arms
2. receiving and compressing chamber
3. Bottom floor

Horizontal hay press

Figure 1 Vertical hay press

The Horizontal hay press (Figure 2) is a 230X75X140 cm (LXWXH) dimensioned press whose body is made from hardwood (eucalyptuses tree). Parts other than the main body were made from available angle iron, round bar, galvanized pipe, and U-channeled cross section metals. Its empty weight is 156 kg and manufacturing cost was about 1973 ETB.

Figure 2 Horizontal hay presses

Horizontal hay press main parts

1. Plunger with arm
2. Receiving chamber
3. Compression chamber
4. Locking fork
5. Wheel
6. Anchor

Evaluation Procedure

Horizontal and vertical hay presses were the two-selected mechanical model, for the study. Based on existing prototype and internet sources both models were modified and manufactured at Bahar Dar Agricultural Mechanization Research Center and preliminary test was carried out for checking proper functionality of the presses in the center.

Then after through discussion was carried out with respective Woreda Agriculture and Rural Development Office experts and development agents and participant farmers were selected from East Gojjam Zone, Dejjen Woreda and West Gojjam Zone, Bahir Dar Zuria Woreda. Experience on preparation of animal feed, awareness about the improved technology, and potential for forage production were considered as the criteria for selection of farmers.

In each selected test site, both hay presses with full accessories were delivered for participants. Selected farmers were trained on operation and handling of improved hay presses. Demonstration was carried out in the presence of selected farmers and some other from the surrounding areas. Participants were encouraged to evaluate and comment on the performance of improved hay presses.

Both hay presses were tested and evaluated for their capacity. Testes were conducted in three replications, with a total of nine observations using single operator. The age and the weight of operator at Andassa test site was 22 years and 50 kg, respectively. Data was collected by using the same operators to operate both machines using natural pasture hay (grass) as test material. Human and cart caring capacity were determined by taking three replication with a total of nine observations for each. Required area, /volume of baled and un-baled hay were determined.

Baling time was measured by stopwatch and defined as the total time required from start of preparation of tightening rope, bale formation, till the end of double tight of the pressed square bale. All bales were wrapped using plastic rope twine spacing. The length, width, and height of all bales were measured to the nearest 1 cm precision to allow calculation of bale area and density. Each bale was weighed to the nearest 0.5 kg precision with 50 kg capacity spring balance. Three samples were used for moisture content determination in which samples were oven dried at 105ºC for 24 h.

Hay presses described theoretically and practically for the farmers, first in each sites, provided theoretical explanation of the use and benefit of the machines for an average of 20 farmers, and secondly practical demonstration was done. Finally, in all trail site discussion was held among farmers, development agents, and Woreda expert on merit and demerit of hay presses. All participants forwarded their opinion regarding the presses performance and other things they consider to be improved. Information was collected and recorded on required improvements, effectiveness, and suitability of the supplied hay presses. The analysis of the data was done by SPSS statistical package using ANOVA and paired samples test.

Results and Discussion

The two improved models of manual operated hay presses were evaluated with respect to their technical performance and farmers view. The technical performance result obtained from Andassa kebele trial site is shown on Table 1. It is the summary of performance parameters of the machines.

As shown on table 1 the differences were seen between presses regarding baling time, bale output, and density. The vertical hay press shows better performance on baling time, output, and density. The statistical analysis on table2 shows that, the mean difference between the presses regarding density and baling out put is highly significant.

In the vertical hay press the operator can use his/her body weight to press the hay. Therefore, this condition assists to reduce energy and facilitate easiness of operation. The horizontal one requires more energy than the vertical because of its pressing pad unit which slides over round bars produces high frictional force reducing operator's efficiency and speed.

Table1: Performance data of hay presses obtained at 10% moisture content of hay using single operator

No	Baler type											
	Vertical press						Horizontal press					
	Baling time (min.)	Bale weight (kg)	Bale Volume (m^3)	Density (kg/m^3)	Output (kg./h)	Bale Area (m^2)	Baling time (min.)	Bale weight (kg)	Bale Volume (m^3)	Density (kg/m^3)	Output (kg./h)	Bale Area (m^2)
1	16.00	10.00	0.11	89.29	37.50	0.32	19.00	10.60	0.16	67.09	33.47	0.45
2	20.00	11.00	0.12	89.43	33.00	0.35	20.00	11.00	0.15	72.85	33.00	0.43
3	18.00	9.40	0.11	87.04	31.33	0.31	17.00	10.40	0.14	74.29	36.71	0.40
4	10.00	9.00	0.11	83.33	54.00	0.31	17.00	10.80	0.16	68.35	38.12	0.45
5	12.00	10.80	0.11	96.43	54.00	0.32	17.00	11.20	0.15	77.24	39.53	0.42
6	11.00	10.00	0.12	81.30	54.55	0.35	19.00	11.00	0.14	78.57	34.74	0.40
7	15.00	10.80	0.12	87.80	43.20	0.35	18.00	11.20	0.14	80.00	37.33	0.40
8	15.00	9.80	0.12	82.35	39.20	0.34	15.00	10.00	0.17	60.61	40.00	0.47
9	10.00	10.00	0.12	81.30	60.00	0.35	15.00	10.00	0.14	71.43	40.00	0.40
Overall mean	14.11	10.09	0.12	86.47	45.20	0.33	17.44	10.69	0.15	72.27	36.99	0.42

Table 3 shows the mean performance parameters of carts loading capacity and area required during transportation and store of the baled and un-baled hay. The mean loading capacity of animal drawn cart, with un-baled hay and baled hay made by horizontal and vertical hay presses were 119.20, 181.60 and 192.40 kg, respectively. This indicates that averages loading capacity of animal drawn cart has an advantage to transport grater mass of baled hay than the un-baled hay. The average area required for a single cart loading hay is 3.70m^2, 1.69 m^2 and 1.33m^2 for traditional, horizontal and vertical hay presses, respectively. Therefore, pressed hay has an advantage over the traditional using less area for grater mass of hay (Table 3). The reason is that compressed hay gets more weight and requires less area than unbaled hay. It also gives convenient loading condition, more preferred by cart owners. Furthermore, it was clearly observed and farmers also indicated that hay loss by dropping on the track during transporting un-baled hay for longer distance with animal drawn carts is high level of concern for owners. This loss is usually aggravated by wind during windy days.

Table 2: Statistical analysis result of vertical and horizontal hay presses on baling output (C) and density (D) using paired samples t-test.

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	VHPD	86.4744	9	4.97872	1.65957
	HHPD	72.2700	9	6.19900	2.06633
Pair 2	VHPC	45.1978	9	10.61749	3.53916
	HHPC	36.9889	9	2.72525	.90842

Paired Samples Test

	Paired differences					t	df	Sig. (2-tailed)
	Mean	Std. deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pair 1	*VHPD - HHPD	6.57074	2.19025	9.15373	19.25516	6.485	8	.000
Pair 2	*VHPC - HHPC	9.53809	3.17936	.87727	15.54051	2.582	8	.033

*VHPD- vertical hay press density HHPD - horizontal hay press density
*VHPC- vertical hay press capacity HHPC - horizontal hay press capacity

The observation taken at Bahir Dar Zuria Woreda shows that the market price of a bundle hay that weight up to 10 kg costs up to 15 birr and for a single cart that weight up to 150 kg cost up to 260 Birr during summer season. Therefore, even though there is no practice of selling the baled hay, farmer can sell single baled hay with the same weight at the price of 25Birr. From a single cart that can carry an average of 18pcs a total of 459Birr can be obtain. This indicates that baling hay beyond conserving of the nutritional value of the feed and connivance transporting the long way to the market with out losses, has benefit of generating about 190ETB additional income over the traditional system.

Generally due to the provided training and demonstration of the mechanical presses, farmers developed knowledge about the importance of baling of hay. They said that using these machines will help them to easily calculate annually feed requirement for their animals. Determining the rate of feeding per animal, proper storing of the feed, easy transportation by human labor and animal drawn carts and conservation of nutritional value of the feed were the main advantages farmers indicated when introduced with the baling machines. Finally, most of the participant farmers gave their view that the vertical press is better than the horizontal one due to its better out put rate, less power requirement, lower

cost and reduced overall weight. On the other hand, when easiness of extracting the baled hay out of the chamber and enabling conditions for longer working period are considered, farmers asserted that the horizontal one is more preferable to the vertical one. Among farmers evaluation parameters given above some of them were supported by figures and found acceptable as indicated on the test results (Table 1).

Table 3; Hay weight to be carried and Space required during transporting and storage by Animal drawn cart

No	Baled with Vertical press		Baled with Horizontal press		Un-baled	
	Hay Weight and Area					
	Bale weight (kg)	Bale Area (m^2)	Bale weight (kg)	Bale Area (m^2)	Hay weight (kg)	Hay Area (m^2)
1	180.00	1.28	190.80	1.80	116.60	3.64
2	198.00	1.40	198.00	1.72	127.00	3.96
3	169.20	1.24	187.20	1.60	133.20	4.16
4	162.00	1.24	194.40	1.80	111.30	3.47
5	194.40	1.28	201.60	1.68	112.32	3.50
6	180.00	1.40	198.00	1.60	112.96	3.52
7	194.40	1.40	201.60	1.60	114.50	3.57
8	176.40	1.36	180.00	1.88	120.00	3.74
9	180.00	1.40	180.00	1.60	123.50	3.85
Avg.	181.60	1.33	192.40	1.69	119.20	3.70

The other thing observed during testing time was that the pressing arms of the vertical hay press were broken and the chambers detached while in operation. This happened after extended pressing work. Based on this breakdown, the research team has concluded that the joints and the arm of this model should be highly strengthened. Participant farmers also gave their opinion that the machine requires in-farm transport mechanism which will facilitate mobility of the device. They also emphasized that minimizing the selling price and reducing machines overall weight are some of the issues that need to be addressed as soon as possible.

Conclusion and Recommendation

The vertical and horizontal hay presses can be manufactured by small workshops. The total cost for manufacturing theses presses will be acceptable by farmers particularly for those who are partially or fully engaged on animal fattening activities. In addition, farmers can be benefited by selling baled hay at higher price than the traditional market way, and by giving renting service to balers they can obtain additional income. Moreover, the technologies have very low maintenance cost, they are simple in construction, and operation. Therefore, they can have higher rate of returns.

But, even though both hay presses were able to make baled hay, farmer's comments and technical test result show that the vertical hay press has better performance with regard to the bale out put, cost, and weight and energy requirement. So, for better livestock productivities in the region, particularly for animal handling and fattening activities, haymaking technologies or balers should be introduced at a relatively larger scale. These machine not only enhance feed preparation processes, but also improve the income generation potential of Small-scale dairy holders. Therefore, the hay presses, especially the vertical hay press model is recommended for further on-farm promotion.

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