DEVELOPMENT AND EVALUATION OF OFF-FIELD HYDRAULIC MOBILE RICE STRAW BALER

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ABSTRACT

Majority of rice straw still unused, together with the unfavorable effects of field burning, environmental pollution and GHG emissions caused by it. Same time, straw baling has not been improved much to fit small-scale farming systems. Therefore, a small-scale mobile baler for baling straw piles created by stationary threshers or collected after combine harvesters has been developed to provide suitable bales' weight and dimensions to fit small-scale farmers' need and easy to be handled. The hydraulic based baler was manufactured in local workshop to be operated by 5-10 hp engine or 3 to 10 hp electrical motor. Manufactured baler has been tested and evaluated in International Rice Research Institute, Los Baños, Philippines during year 2013-2014. Major components of baler were; hydraulic system consisted of vane pump, top-ported pressure filter, pressure gauge, sight gauge, return filter and piston with 600 mm, 0.083 m/s and 0.069 m/s stroke length, forward speed and return speed respectively; baler body with compression chamber has dimensions of 600 x 350 x 450 mm (height x width x length); and transmission systems. Testing and evaluation of the baler gave chance to enhance baling mechanism and its reliability. The relations between straw characteristics, moisture content (MC) and bales density have been addressed, where 244.63 kg m^{-3} average bales density obtained from threshed straw with 49.84 % average MC with 23.63 kg average weight. For lower MC, 6.31, 7.77 and 8.21 % bales density were 130.37, 145.63 and 137.53 kg m^{-3} respectively for different rice straw. Baling straw with same characteristics at different MC reduced bales density by 21.3 % when MC reduced from 25.23 to 7.77 %. Baling shorter straw gave higher bales density with 293.22 kg m^{-3} with 28.33 kg average bales' weight. Rice straw baled under low moisture content when gets stored indoors for 22 days, always had an increase in its moisture content as

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well as the density. Also, for the verities that stored indoors long time (62 days), moisture content increased.

Keywords: Rice straw, straw characteristics, stationery baler, densification, hydraulic baling

INTRODUCTION

Along with the progress in the rice production system, the amount of straw will increase. About 620 million tons of rice straw produced in 2008 in Asia and now approximately 731 million tons per year rice straw is produced globally (Africa: 20.9 million tons, Asia: 667.6 million tons, Europe: 3.9 million tons, America: 37.2 million tons, and Oceania: 1.7 million tons) ***(Gummert, 2013; Sarkar and Aikat, 2013)***. Only about 20% of rice straw was used for purposes such as producing ethanol, paper, fertilizers and fodders and the remaining amount is either removed from the field, in situ burned, piled or spread in the field, incorporated in the soil, or used as mulch for the following crop ***(Hanafi et al., 2012)***. In many developing countries, straw collection always was remained dependent on a handful of elderly stationary balers with top-feed ram stroke and wire/plastic twine tie design, and straw was shipped in rectangular bales for instance 0.6×0.5×1.5 m (width, height and length). Bale length varied up to 1.9 m. Mass was typically 100-120 kg/bale, but could be higher, which make this baling system classified as medium/large baling system. There is another smaller type of straw bale press is produced to fit the requirements of straw bale size of the client and it can be either used to press rice straw at its hay estate or in its chipped estate. Metal string or plastic ropes can be used to tie the straw bale, the baler move from place to place near the field to bale manually collected rice straw ***(Garas et al., 2009)***. More development done to improve the working efficiency with adequate safety in such balers e.g. ***El-Shal (2005)*** added a unit of straw pick up, packers, means of applying forces to resist the moving of material through the bale chamber, and means of separating consecutive bales. More straw baling machines came later and now are commonly used in some regions, and are ideally suited for harvesting straw from small fields, and the bale is convenient and easy-to-handle by small-scale producers. ***(Steele et al., 2009)***

In Pakistan, a mobile straw baler was designed and developed at the Agricultural Mechanization Research Institute (AMRI), Multan, Pakistan. The design parameters of this mobile straw baler were based on local farm size, crop wastes and field conditions. The baler made bales of size approximately 0.391 x 0.457 x 0.635 m, handling of the bales was simple and easy. The loading and transportation of bales with a truck and trolley was easy and cheaper than that of the straw. The cost of manufacturing was $ 3800 and the average weight of wheat straw bale was 34.6 kg. However no data about the performance of this baler with rice straw ***(Yasin, 2012)***. In India and china, systems needed for the collection, processing, and transportation of rice straw have been developed recently. Many balers are available for collecting rice straw with bale size of 0.46 x 0.36 m (height and width) with variable length from 0.4 to 1.1 m and bale weight is from 10 to 35 kg depending on bale length and crop condition (***Mangaraj and Kulkarni, 2011; HSCUP, 2011)***. Some of straw bales get transferred by medium and big trucks to nearest power plants (***Romana,*** ***2013).*** In some African countries, e.g. in Ghana, the rectangular balers are used now in some places for baling rice straw mainly as cattle's feed ***(MOFA, 2013)***. But no local manufacturing or assembling operations running in the country, all available balers are imported.

However rice threshers have been used widely and farmers will continue to use them for more many years, even with increasing the number of combine harvesters and reapers, no better utilization of straw till now. Also, the power sources available in most of developing counties are normally in term of small engines and two wheel tractors (2WTs), beside small/medium four wheel tractors (4WT) in some places. So, manufacturing and testing stationery small mobile baler was the aim of this study, where farmers can bale and easily transfer the amount of straw left after threshing operation or manually collected after combine harvesting.

MATERIALS AND METHODS

Hydraulic based baler was manufactured in local workshop in Los Baños city, Philippines to be operated by small-size engines from 5-10 hp or to be driven by electrical motor 3-10 hp to operate a hydraulic cylinder producing linear force and motion for the piston rod in a certain stroke by employing the flow of pressurized fluid. Manufactured baler has been tested and evaluated in International Rice Research Institute, Los Baños, Philippines during year 2013-2014. Major component of the baler were; hydraulic system consisted of PVR-15 vane pump with 400-1500 psi and keyed shaft standard, top-ported pressure filter, pressure gauge, sight gauge, return filter and piston with 600 mm, 0.083 m s^{-1} and 0.069 m s^{-1} stroke length, forward speed and return speed respectively; baler body with compression chamber has dimension of 600 x 350 x 450 mm (height x width x length) from inside; attached engine and transmission systems. The baler has been tested three times after assembling followed by baling rice straw coming from different rice varieties and harvesting methods under constant motor speed (in case of using electric motor) of 1790 rpm, pump speed of 1128 rpm and 400-600 psi pressure applied.

1. Technical Consideration

Main technical considerations to manufacture the stationery baler were listed as below:

1- The small size of holdings and high cost of imported baling machines are indicators to have small-size bales produced economically. And to be driven by small size engines or electrical motors.
2- Avoiding complicated parts in baler parts which cannot be achieved with limited available skill workers and materials.
3- Providing suitable bales' weight and dimensions to be easily handled by one person.
4- Obtaining well-formed high density bales with straw pressing mechanism

2. Pre-design Assumptions

As we target producing economical small-scale bales, from literature review the dimensions of small scale bales are being varied, where, the most common bales dimensions around ± 400 x 500 x 600 mm, we assumed that we can get bales with 600 x 350 x 450 (h x w x l) mm with an overall size of 0.0945 m^3 which give us reasonable weight (Figure 1).
Target baling density was from 140-180 kg m^{-3} as recommended due moister variation, expected weight should be from 13 to 25 kg/ bale.

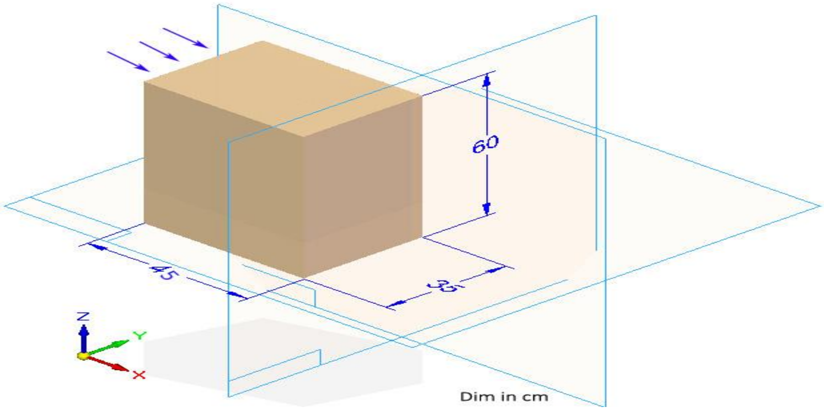


Figure 1: Assumed bale's dimensions

For the straw coming from threshers 'output, considering the two available options; 1) manual feeding by one person or, 2) 1000 kg h^{-1} as thresher feeding rate (average), straw coming to the baling chamber around 70 %, 700 kg (after excluding the amount left on field and as of 1:1 straw ratio). In both cases we assumed that there is 700 kg of straw to be baled within one hour. 700 kg to be baled into certain number of bales with 18 kg average weight, then baling efficiency will be 38 bales/h. That is happening only if the baling operation is continuous and every formed bale come out from baler without interface the next bale. That number of bales can be achieved only with a mechanical plunger compression system with a flywheel. But, the required parts and technical skills need to generate this design wasn't exist in local workshops. The alternative option was using a hydraulic system which was available instead of the using mechanical plunger; using hydraulic system is limiting the number of expected baled as hydraulic circuits provide slower motion to compression piston. As described earlier by ***Kepner et al (1987)***, from 150 to 180 kg cm^{-2} (which hydraulic system can easily provide) is enough force to generate bales with densities varied from 130 to 300 kg m^{-3} according to the moisture content of the straw. So, the hydraulic system was used to operate the compression piston.

3. Hydraulic System

Using 5 to 10 hp engine [or electrical motor (3–10 hp)] is enough to operate a hydraulic cylinder to produce linear force and motion for the piston rod in certain stroke by employing the flow of pressurized fluid. The fluid is supplied by a mechanical pump. During compression, oil from the pump passes through a directional control valve, is split by the flow divider and fed to the full-bore side of the compression piston. Once it reaches the hydraulic cylinder, the pressurized oil exerts pressure upon the area of the piston inside the cylinder barrel. This pressure produces a large force that moves the piston. In order to prevent the hydraulic pressure from being lost by passing over the piston to the opposite side, hydraulic seals are installed in the piston, in our case; flow from pump is used to produce a piston velocity of approximately 0.14 m s^{-1}. A compressor and gauge are used to regulate the pressure within the system. Typical hydraulic cylinders circuit and component used with baler as in Figure 2.

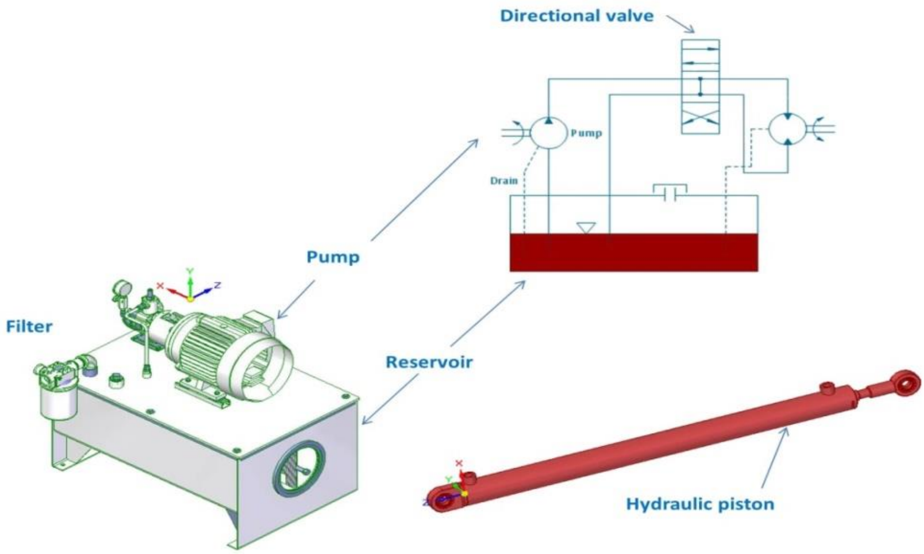


Figure 2: Simple acting cylinder circuit and components

Major components of the hydraulic system were: vane pump with specification listed in Table 1 and Figure 3, top-ported pressures filter (Table 2), pressure gauge up to 2000 psi (0-140 kg cm^{-2}), sight gauge which gives an indication of current fluid level, and return filter.

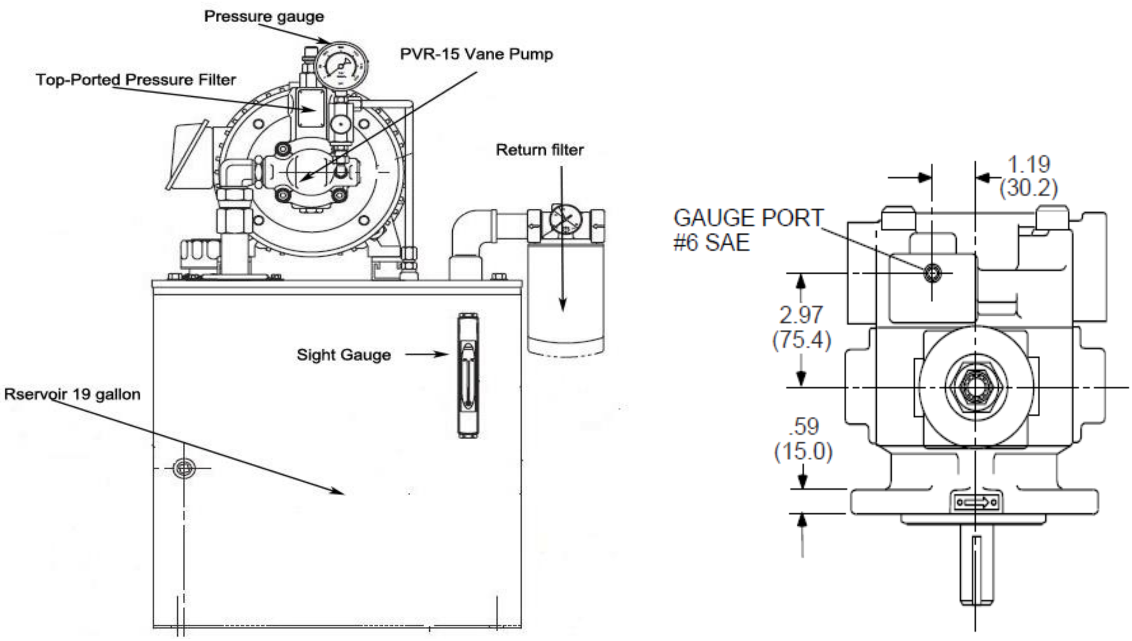


Figure 3: PVR-15 vane pump and its dimensions (15B 15-RF-0-5-E, actual 400 -1500 Psi - keyed shaft standard) used in the hydraulic system

Table1: Typical performance specifications of PVR-15 vane pump used in the hydraulic system

Pump Size 15b 15 - flanged mounted SAE "B" 2-Bolt			
Volumetric displacement		cu. in./rev. (ml/rev.)	2.4 (39.3)
Pump delivery at 1750 rpm		91.5 psi (6.3 bar)	gpm 18.7 (lpm 70.8)
		Rated pressure	gpm 15 (lpm 56.8)
Compensated pressure ranges		Max.	psi 2000 (bar 160)
		Rated	psi 2000 (bar 138)
		Min.	psi 400 (bar 28)
Operating speeds		Min.	rpm 1400
		Rated, rpm	1750
		Max., rpm	2400
Suction	pressure	Max.	psi 20 (bar 1.40)
		Min.	in./Hg 7
		Specific gravity < 1	bar -0.25
	Fluid velocity	Max.	ft./sec. 5 (m/sec.1.5)
Case Crain	Nominal flow at deadhead pressure	1000 psi (69 bar)	gpm 0.5 (lpm 1.9)
		1500 psi (103 bar)	gpm 0.8 (lpm 3.0)
		2000 psi (138 bar0	gpm 1.2 (lpm 4.5)
	Maximum case pressure	psi 10 (bar 0.7)	

Table 2: Top-Ported Pressure Filter

Top-Ported Pressure Filter	
Rating:	Up to 20 gpm (75 L/min) for 150 SUS (32 cSt) fluids
Max. operating pressure:	3000 psi (210 bar)
Rated fatigue pressure:	2400 psi (165 bar)
Temp. range:	-20°F to 225°F (-29°C to 107°C)
Porting Head: Element Case:	Aluminum
Weight of NF30-1N: weight of NF30-1NN:	3.4 lbs. (1.5 kg) 4.4 lbs. (2.0 kg)
Element change clearance:	4.50" (115 mm)

4. Evaluation, Study Variables and Parameters

To define the relationship between bales density and rice straw condition at constant applied pressure, piston speed, bale chamber size, cycle of loading and feed rate, the variables (factors having an influence on bales density) were; different moisture contents; length of straw (harvesting methods); and varieties. Different levels have been tested to represent different moisture may exist after harvesting and according to the number of days after harvest or weather condition. Harvesting methods included combine harvesting and manual harvesting which either followed by manual or axial flow threshing, which is affecting straw length. the evaluation experiments done under constant stroke length of 600 mm, piston forward speed of 0.083 m s^{-1} piston return speed of 0.069 m s^{-1}, compression chamber with dimension of 600 x 350 x 450 (h x w x l) mm.

5. Manufacturing and Pre-testing of The Hydraulic Baler

After assembling different baler parts and components including the hydraulic system, three consecutive tests were done to enhance the baling mechanism, bale delivering system, and straw feeding.

5.1. First Test

No issues or problems found regarding the use of hydraulic system or the attached engine, major problems found were related to; 1) feeding straw with required compression force in front of the compression rod sheet (Figure 4 c); 2) difficulties to get formed bales out of the compression chamber (Figure 4 b), it is supposed to be manually pulled away for tying. There was no easy solution to overcome the problem of getting the bales out of the baler except changing the way of getting bales out from side way to the back end of the baler. Then, the baler outlet opening has been changed to be at the end using the compression piston to push the bales out of the baler to be tied. The problem of compression force required in front of the compression piston sheet solved by adjusting the hopper to make a smooth flow of the straw and to be an option to attach it or not according to the straw situation and the speed of straw feeding.

5.2. Second Test

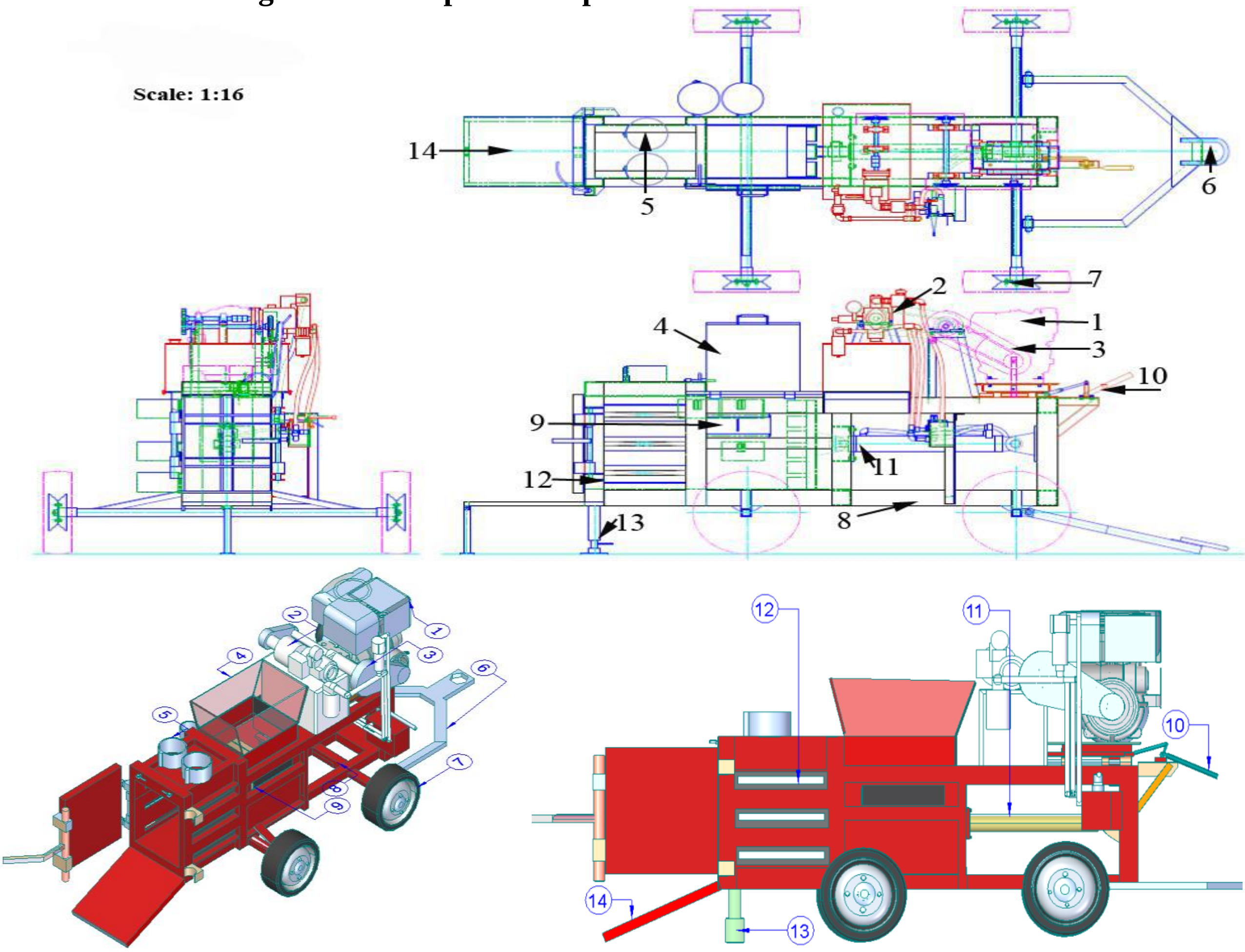
Second test came with better results, and the observations were related to the tying mechanism which normally being done manually. One observation was to add two more tying strings perpendicularly to the other three main strings (Figure 4 e and f). Other modifications followed second test which included but not limited to; better screw bolt stand, more tying string houses, changing the hydraulic system control arm to work up and down instead of right and left with adding lock to provide continues movement of the compression piston without fully human control.

Figure 4: Consecutive testing to enhance the baling mechanism and tying system

5.3. Third Test

Mainly was to test the reliability of the system for long time operation, and the system worked well without any observation of low pressure, leakage or overheating. Successfully, the baler delivered 40 bales continuously. Robin model EY23 air-cooled 10 hp gasoline engine or electrical motor have been used in testing (Figure 5). The final geometric and technical drawings of baler are shown in Figure 6.

Figure 5: Two options to operate the manufactured baler



1) Engine, 2) hydraulic system, 3) transmission system, 4) hopper, 5) twine holder, 6) one-point hitch, 7) wheel, 8) frame, 9) sliding window, 10) placement arm, 11) piston, 12) tying opening, 13) screw stand bolt, 14) straw skating sheet

Figure 6: Geometric and technical drawing of manufactured baler

RESULTS AND DISCUSSION

Densification experiments have been done to evaluate the baler output under different rice straw condition.

With mix varieties harvested by combine and have stem length of 448 mm, average density was about 176.63 kg m^{-3} when straw got baled in same harvesting day under high moisture content of 25.23%. same straw has been densified to 145.63 kg m^{-3} when baled after 13 days at lower moisture content (7.77 %). percentage decrease in density was 17.6 % when moisture content in straw decreased by 69.2 % (Figure 7). With two mix varieties (NSIC RC222 and NSIC RC238) which manually harvested and panicle threshed with short stem length of 276.67 mm, average density was about 293.22 kg m^{-3} when straw got baled after 6 days from harvesting at high moisture content of 27 %. Same straw has been densified to 203.24 kg m^{-3} when baled after 22 days at lower moisture content (9.26%). percentage decrease in density was 30.7%. The high density obtained under high and low moisture content may be achieved because of the more densification applicable to short rice straw stem compared to the normal stem lengths (Figure 8).

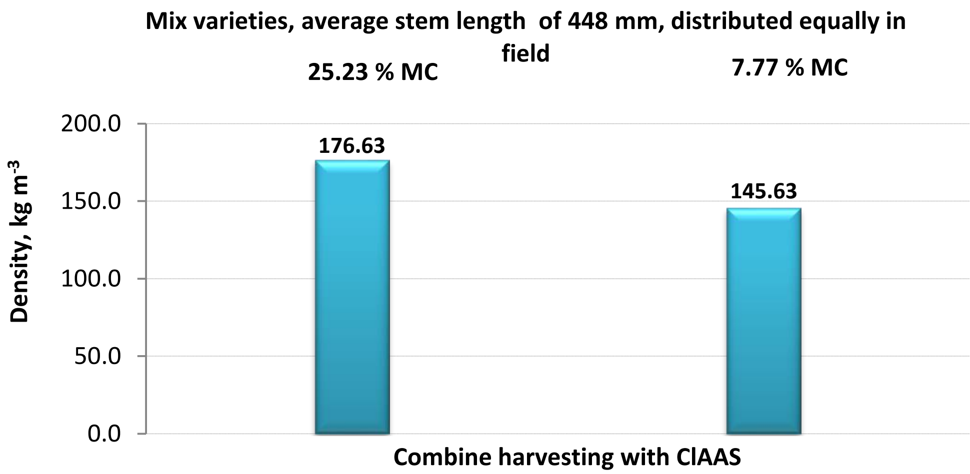


Figure 7: Densification of mix varieties harvested by combine and have stem length of 448 mm.

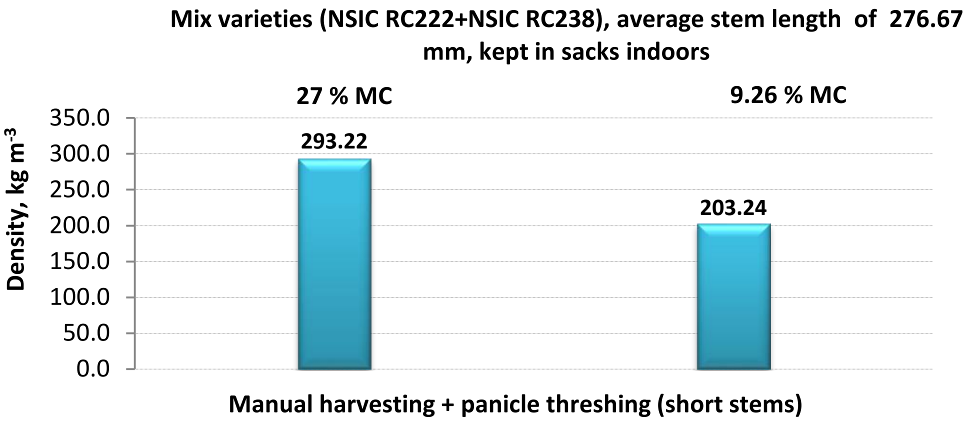


Figure 8: Densification of manually harvested and panicle threshed with short stem length of 276.67 mm.

Manually harvested rice variety NSIC RC222 followed by axial flow threshing which has stems with average lengths of 640 mm gave density of 148.24 kg m^{-3} when baled with 8.65 % moisture content after 22 days of harvesting. Same straw has been densified to 137.53 kg m^{-3} when baled 2 days after harvesting at 8.21 % moisture content (Figure 9). Percentage increase in density was 7 % and the straw absorbed more moisture from surrounding air within 22 days of storage inside door.

Rice straw baled under low moisture content when gets stored indoors long time, always had an increase in its moisture content, e.g. NSIC RC238 variety which harvested manually and threshed by axial flow threshed with 444 mm stem length, when stored for 62 days, its moisture content increased from 6.31 to 8.78 %. And, the density in this case increased by 3.4 % with the increase of the moisture content. For the two varieties NSIC RC222 and NSIC RC238 which have been manually harvested and manually threshed with 626 and 598 mm stem length, the percentage increase of moisture content was 29 % and 31.6 % respectively when stored for 62 days prior to baling. In both verities NSIC RC222 and NSIC RC238, the density of straw has been increased by 4.1 and 2.7 % respectively (Table 4 and Figure 10). Type II sum of squares analysis showed the high significance of the moisture content in baling densities with developed baler as known fact and expected results with standard division of 48.713.

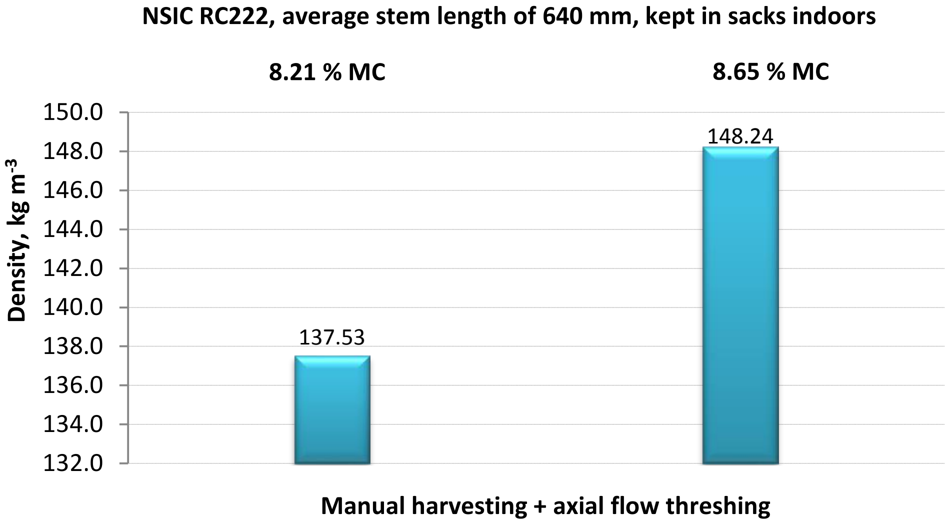


Figure 9: Densification of Manually harvested rice followed by axial flow threshing.

Table 4: Characteristics of different baled rice straw after 62 days of inside door storage.

Variety	Date of baling in 2014	Harvesting method	Stem length, mm	Stem thickness, mm	Days after harvesting	Moisture content, %	Density, kg/m^3
NSIC RC 238	04, April	Manual harvesting +axial flow threshing	444	3.03	2	6.31	130.37
NSIC RC 238	29, May	Manual harvesting + axial flow threshing	444	3.03	62	8.78	134.74
NSIC RC222	10, April	Manual harvesting + Manual threshed	626	3.20	10	6.45	149.07
NSIC RC222	29, May	Manual harvesting + Manual threshed	626	3.20	62	9.12	155.25
NSIC RC 238	10, April	Manual harvesting + Manual threshed	598	2.90	10	6.02	134.4
NSIC RC 238	29, May	Manual harvesting + Manual threshed	598	2.90	62	8.8	138.09

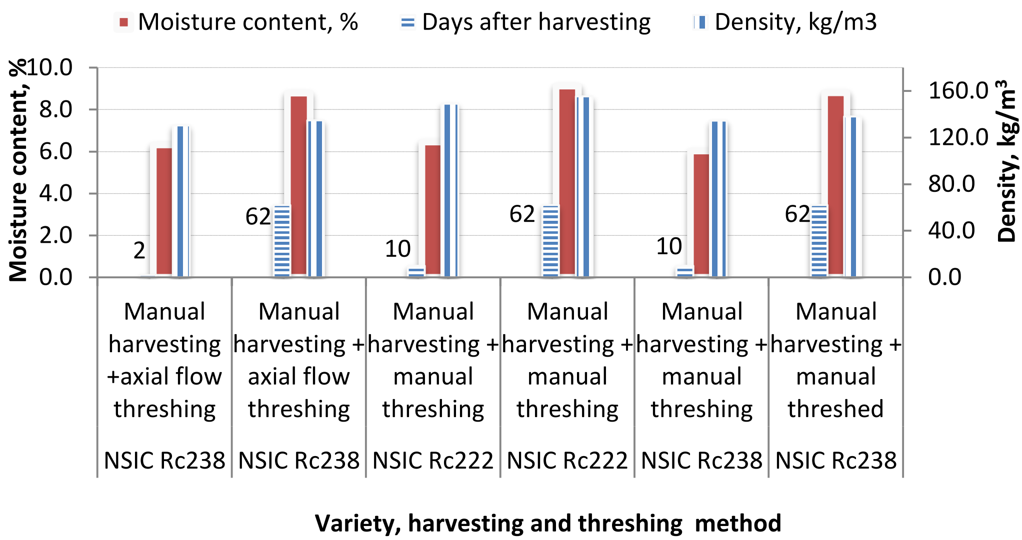


Figure 10: Densities of different rice straw bales after 62 days indoor storage.

Along with the effect of moisture content of rice straw baling, both rice straw length and stem thickness have been measured before baling. Results showed the significance of straw length on density, where short straw with average 276.67 mm which came due to manual harvesting followed by panicle threshing gave highest densities with averages of 293.22 and 203.24 kg/m^3 at moisture content of 27 and 9.26 % respectively. While longer stems which have 448 to 626 mm length gave densities from 130.37 to 176.63 kg/m^3 at different moisture contents as shown in Figure 11. All rice straw thicknesses were in range from 2.63 to 3.30 mm in average and have no significant effect on bales' densities.

CONCLUSIONS

The developed baler has ability to produce bales with recommended and designed dimensions with bales weight ranged from 11.13 to 28.33 kg and 600 x 350 x 450 mm as bales dimensions. For mix varieties which harvested by combine and have average stem length of 448 mm, density decreased by 17.6% when moisture content in straw decreased by 69.2 %. Baling manually harvested mix varieties with average stem length of 276.67 mm gave highest bales' densities of 293.22 kg m^{-3} at high moisture content of 27% and 203.24 kg m^{-3} at lower moisture content (9.26%).

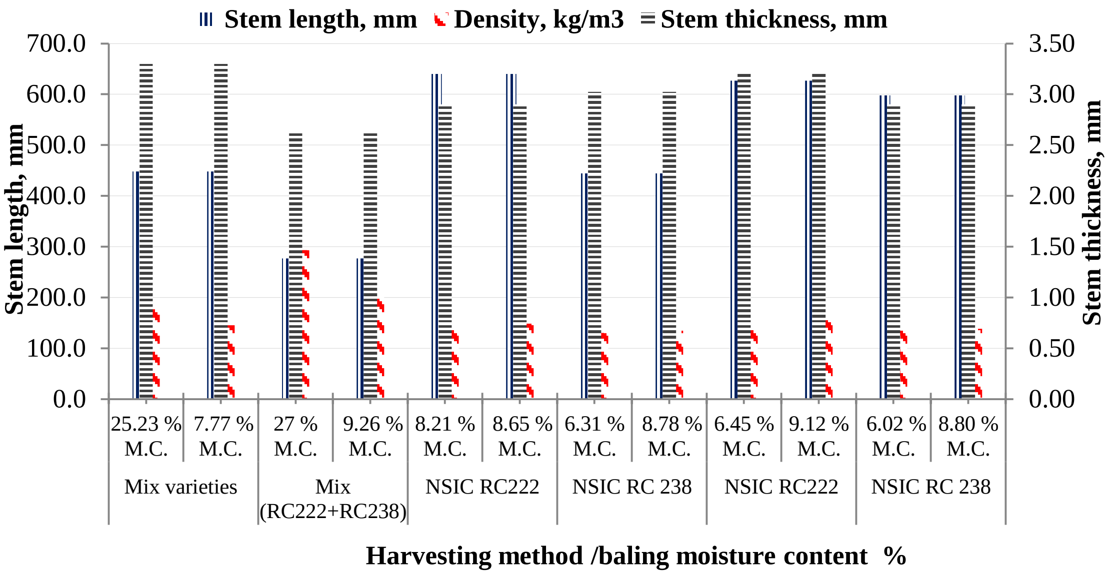


Figure 11: Effect of rice straw length and thickness on bales' densities.

Storing straw indoors with lower moisture slightly led up to increase in straw moisture content e.g. in case of manually harvested rice variety NSIC RC222, moisture content increased from 8.21 % to 8.65 % when straw stored for 22 days indoor, which gave increasing in density by 7 % in average. Other rice straw stored indoors under low moisture content for long time had same trend of increasing their moisture content with increase bales densities.

Distribution such simple small/medium scale balers within farmers will assist in baling straw left after threshing or manually collected after combine harvesters in small or large farms. Results are suitable to guide different stakeholders to bale rice straw under different conditions. And that will enhance straw handling, transportation and storage which are important to start any rice straw based conversion technology and utilization. However, further studies need to address the economic use of such machines compared to big/medium size balers with force analysis and energy requirements for operating the baler.

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الملخص العربي

تطوير وتقييم آله هيدروليكيه متنقله لتبيل قش الارز

د. رشاد عزيز حجازي*

الهدف الرئيسي من البحث هو تصنيع آله تبيل لقش الأرز مُشغله بنظام هيدروليكي ومُتنقله لتسهيل تبييل قش الأرز الناتج من آلات الدراس الثابتة أو المُجمع من الحقل خلف ألات الحصاد. تم تصميع الآله بعد أخذ الاعتبارات الفنيه الأتيه في الأعتبار:

١- تصنيع الآله لتناسب المساحات الصغيره وبتكلفه مناسبه لشريحه عريضه من المزارعين.
٢- انتاج بالات من قش الأرز باحجام وأوزان سهله النقل والتخزين ويمكن تداولها وحملها بشخص واحد.
٣- التغلب علي مشكله تراكم قش الأرز علي جوانب الأراضي الزراعية والممارسات الغير مرغوب فيها بتجهيز قش الأرز للتخزين أو لاستخدامات الطاقة الجديده في صوره يسهل ادارته.
٤- تصميم سهل ويمكن تصنيعه في الورش المحليه وبخامات متاحه وبامكانيات فنيه بسيطه.
٥- يمكن ادارتها بمصدر قدره صغير ومتاح كالموتور الكهربي أو محركات بقدره من ٥-١٠ حصان.

تم تصنيع آله التبيل في احدي الورش المحلية في مدينه لوس بانوس اقليم لاجونا في الفلبين بخامات محليه وجهاز هيدروليكي معدل ليناسب الغرض من استخدامه وتم اجراء ثلاث اختبارات لضبط وتعديل الآله اثناء التصنيع وتلافي بعض مشكلات التشغيل اثناء الاختبارات. الأختبار الأول أظهر صعوبه اخراج البالات بعد عمليه الكبس داخل غرف الكبس من الجانب وتم تعديل فتحه خروج البالات ونقلها الي الخلف وكذلك تعديل شكل قادوس التغذيه ليكون اكثر ملائمه، الأختبار الثاني اظهر صعوبه عمليات ربط البالات يدويا وتم اضافه خيوط ربط اضافيه

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لاحكام وسرعه ربط البالات، الاختبار الثالث تم لقياس الأداء لفتره تشغيل طويله لكبس عدد أربعين باله دون وجود مشاكل فنيه في الآله. بعد التاكد من عدم وجود مشكلات فنيه اثناء التشغيل تم اختبار الآله في تجربه لتبيل قش الأرز الناتج من عمليات الحصاد المختلفه وباطوال مختلفه وعند محتوي رطوبي متغير. تم أخذ عينات من قش الأرز الناتج من عمليات الحصاد اليدوي المتبوع باستخدام آلات الدراس الثابته أو المجموع يدويا بعد الحصاد بآلات الحصاد الجامعه. تم ايضا استخدام قش الأرز الناتج من اصناف معينه أو خليط من اكتر من صنف. ولصعوبه تحديد المحتوي الرطوبي وتثبيته اثناء الاختبارات لتعدد اوقات الحصاد وطرقها، تم قياسه قبل وبعد عمليات التبيل وربطه بكثافه البالات مع الاشاره لأطوال سيقان قش الأرز المستخدم وسمكها.

<u>وقد أوضحت النتائج أن:</u>

الأله لها القدرة علي انتاج بالات باوزان من ١١,١٣ الي ٢٨,٣٣ كجم والتي يمكن تحريكها بسهوله. الأبعاد النهائيه للباله المنتجه كانت ٣٥٠x٤٥٠x٦٠٠ مم^{٣} والتي تجعل تصنيف البالات ضمن الأحجام الصغيره .

قش الأرز بمتوسط طول ٤٤٨ مم والناتج من حصاد أكثر من صنفيين من محصول الأرز بآله الحصاد المجمعه (الكومباين) أعطي متوسط كثافه ١٧٦,٦٣ كجم/م^{٣} عندما تم تبيله في نفس يوم الحصاد عند محتوي رطوبي ٢٥,٢٣ %. نفس الماده اعطت كثافه ١٤٥,٦٣ كجم/م^{٣} عند عمل بالات بعد ١٣ يوم من الحصاد ومحتوي رطوبي ٧,٧٧ %.

قش الأرز الناتج من صنفي الأرز NSIC RC222 و NSIC RC238 والمخلوطين معا بعد الحصاد اليدوي واستخدام آله الدراس الثابته وبمتوسط طول ساق ٢٧٦,٦٧ مم، أعطي متوسط كثافه ٢٩٣,٢٢ كجم/م^{٣} عند محتوي رطوبي ٢٧ % وبعد ٦ أيام من الحصاد. في حين أنتجت نفس الماده بالات بكثافه ٢٠٣,٢٤ كجم/م^{٣} عند محتوي رطوبي ٩,٢٦ % بعد ٢٢ يوم من الحصاد. مع ملاحظه الكثافه العاليه للبالات المنتجه لماده محتواها الرطوبي عالي وذات سيقان قصيره وهو ما يتفق مع معظم الدراسات السابقه.

قش الأرز الناتج من صنف الأرز NSIC RC222 بعد الحصاد اليدوي واستخدام آله الدراس الثابته وبمتوسط طول ساق ٦٤٠ مم ، اعطي متوسط كثافه ١٤٨,٢٨ كجم/م^{٣} عند محتوي رطوبي ٨,٦٥ % وبعد ٢٢ يوم من الحصاد. بينما نفس الماده أنتجت بالات بكثافه ١٣٧,٥٣ كجم/م^{٣} عند محتوي رطوبي ٨,٢١ % بعد يومين فقط من الحصاد. مع ملاحظه زياده المحتوي الرطوبي بعد فتره تخزين القش داخل مبني التجارب لمده ٢٢ يوم. وأيضا ارتفاع في المحتوي الرطوبي لباقي قش الأرز والمخزن داخليا لفترة ٦٢ يوم. سمك سيقان قش الأرز المستخدمه لم يكن له تاثير ولكن السيقان القصيره اظهرت تاثير معنوي علي زياده الكثافه مع زياده المحتوي الرطوبي عند استخدام آله التبيل المصنعه.