ROYAUME DU MAROC

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# AL AWAMIA

## REVUE DE LA RECHERCHE AGRONOMIQUE MAROCAINE

Institut National de la Recherche Agronomique
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# PERFORMANCE EVALUATION OF STATIONARY THRESHERS

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## ABSTRACT

A procedure to evaluate the performance of stationary threshers is discussed. This procedure was then used to evaluate two stationary threshers. Differences in performance between the two machines were observed and are reported.

## I- INTRODUCTION

In many developing countries, much use could be made of small stationary threshers for cereals and legumes. These machines are simple in function and operation and are used in areas that are not accessible to a combine or in areas where the economics do not support the use of expensive combines. Small stationary threshers would be particularly appropriate where crops have been harvested and collected at some central location for threshing by animals.

Procedures and methodology to evaluate the performance of stationary threshers are nonexistent. However, procedures that have been developed by the American Society of Agricultural Engineers (ASAE) can be modified to fit the requirements and operation of a stationary thresher.

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The Prairie Agricultural Machinery Institute (PAMI) has been one of the more active institutions testing combine performance and making reports of the test results available to the public. PAMI uses a combine designated as a reference machine as the comparison to the test combine. This reference machine, when used in varying crop conditions, serves as the standard or normalizations for comparing combines tested in different years and crop conditions.

## II- OBJECTIVE

The objective of this paper is to present the procedure used to evaluate two stationary threshers and report the results.

## III- PROCEDURE

Two stationary threshers were obtained for testing in cereal crops in Morocco. One of the threshers was manufactured by a small manufacturer in Morocco and the second thresher was imported.

The two machines were different in operational characteristics but both accomplished the same function.

The threshers were evaluated using Saada wheat. The procedures used to evaluate the two threshers were developed from ASAE STANDARD : ASAE S396 combine Capacity Text Procedures. The standard for testing combine capacity calls for the comparative testing of one machine relative to another in a particular crop condition. The thresher manufactured in Morocco was designated the test machine and the other thresher was designated the comparison machine.

Performances of the threshers were evaluated by varying total feed rates starting at some minimum total feed rate and increasing until some upper limit was reached. On-farm demonstrations of the test machine during the previous year, indicated a wide range of threshing capacities but with an average grain feed rate of 200 kg/h. Therefore, both threshers were adjusted during pretest runs for optimum performance at that rate.

The total feed rate of a combine can be easily controlled by the forward speed. However, for a stationary thresher where the input is accomplished manually, the total feed rate is more difficult to control. As a result of preliminary tests with manual input, preweighed material of approximately 100, 150 and 200 kg was used for the test runs. The intention was to manually input these preweighed stacks in 15 minutes.

Samples of material other than grain (MOG) and grain were collected at their respective discharge sites. Sample duration time was 30 seconds for both MOG and grain with 3 or 4 samples being obtained during each test run. A box was fabricated to catch all MOG discharged from the machine during the sampling period. Grain samples were obtained by catching at the grain discharge. A grain catch was obtained after each MOG catch.

All MOG catches were evaluated for processing losses. These catches were weighed, sieved and the sieved material passed through a winnowing fan to remove any small debris. The grain recovered from each MOG catch was then weighed and recorded.

All grain catches were subsampled and examined to assess the damage due to cracked and crushed grain. The remainder of the grain samples were winnowed to determine the amount of MOG in the clean grain.

Preliminary test results from the test machine indicated that good threshing with minimal grain damage resulted at a threshing rotor speed of 775 rpm. Grain damage was excessive at the recommended rotor speed of 850 rpm. However, a series of performance tests were later run at the recommended rotor speed.

Preliminary test results from the comparison machine indicated that a rotor speed of 750 rpm was adequate for the threshing process. Rotor speeds in excess of 800 rpm were initially tried but lowered with no loss in threshing efficiency. Grain damage was not the criteria for rotor speed as no grain damage occured during the preliminary tests.

## IV- DESCRIPTION OF THE MACHINES

The terminology of ASAE standard : ASAE S343.1 Terminology for combines and Grain Harvesters was used. Table I lists the specifications for the two machines. A review of this table illustrates that the machines are approximately the same size. The threshing rotor diameters and lengths are relatively the same. The comparison machine has more threshing area because the separating grate is functional for 360 degrees but the cleaning screen is considerably smaller. The specifications for the engine on the test machine were not known.

The test machine is basically a modified hammer mill. Threshing is accomplished by impact with rotor spikes. All input material exits the threshing area through a screen. Thus the straw is reduced into lengths usually less than 5 cm. The thresher has no taillings return. All grain not removed from the cleaning screen is lost in the straw discharge. The thresher has three cleaning fans, two providing wind for the cleaning screen, and one providing a final cleaning for the grain prior to the bagging auger. The wind volume is adjustable by dampers on all fans but the direction is fixed.

The comparison thresher has more components than the test machine, Table I. Operation of the machine was smoother. Threshing is also accomplished by impact with a set of spikes. The straw is, in effect, augered through the trhreshing area by the rotor and discharged with a paddle fan. The straw length is usually greater than 5 cm. The comparison machine has a tailings return. The thresher uses two fans to provide wind to the cleaning screen. The wind volume is also adjustable by dampers but the direction is fixed.

Table I. **Specifications of the test and comparison threshers**

| Machine ID | test | comparison |
|---|---|---|
| Rotor diameter, mm : | 530 | 520 |
| Rotor length, mm : | 1155 | 1060 |
| Separation grate : | | |
| width, mm | 780 | 1060 |
| arc length x diameter | 655 x 540 | 1948 x 620 |
| area, m2 | 0.51 | 2.06 |
| hole diameter x spacing | 20 x 26 | ---------- |
| rod diameter x spacing | ----------- | 8 x 18 |
| Cleaning screen : | | |
| width, mm | 880 | 480 |
| length, mm | 1080 | 300 |
| area, m2 | 0.95 | 0.144 |
| hole diameter x spacing | 10 x 14 | 13 x 18 |
| Tailing return : | No | Yes |
| Rotor spikes : | | |
| rows x no / row | 8 x 22 | 8 x 14 |
| length, mm | 75 | 80 |
| Engine : | | |
| manufacturer | Lister | Kubota |
| Bhp x rpm | est. 10 | 11 x 2400 |
| displacement, cc | -------- | 598 |
| Thresher length, m : | 3. 14 | 3. 10 |
| Thresher height, m : | 2. 43 | 2. 66 |

# V- RESULTS AND DISCUSSION

The weights of the unthreshed input material and of the grain obtained from the test run are given in Table II. The MOG was then determined from the weight differences. The feed rates calculated from the MOG and grain catches obtained during the 30-second sampling periods are given in Table III. Each value is the average of all samples obtained during a test run.

Comparing total feed rate in Table III to the weight of unthreshed material in Table II suggests some inconsistencies. For instance, tests H1 131 and H 1231 were both run with the same amount of input material. Yet comparing the average total feed rates between the two tests would suggest otherwise and illustrates the difficulty of maintaining a steady input of material.

Another measure of the varying inputs during the testing is the MOG/G ratio. In Table II, except for test H0003 and H0528, the MOG/G ratios are fairly consistent when based on total weight. Yet when MOG/G ratios are based on feed rates, as in Table III, more variation is apparent and illustrates the wide variation of total feed rates when material is input by hand.

It was evident from the very beginning of the technical evaluation of the comparison machine that there were problems adjusting the wind volume. The wheat used for the performance tests had a solid stemmed straw. Therefore the straw was heavier than normal. When the wind volume was increased to remove the straw from the cleaning screen, excessive grain was carried off with the straw discharge. When the wind volume was decreased so that grain losses were acceptable, the volume of straw in the tailings return was excessive and plugged the return auger. Therefore, the critical adjustment for this machine and with this particular variety of wheat was the wind. Because of the plugging at acceptable grain loss levels, the comparison machine was evaluated at only two feedrates.

The primary measure of threshing capacity is the maximum rate at which a threshing machine can operate while maintaining an acceptable loss level. PAMI uses a processing loss of 3 % as an acceptable loss level for rating combines. Therefore, the results obtained from the two threshers were arbitrarily compared to the PAMI loss reference.

Figure 1 illustrates the processing losses of the two machines as a function of the total feed rate. There appears to be no difference in processing losses between the two rotor speeds of the test machine.

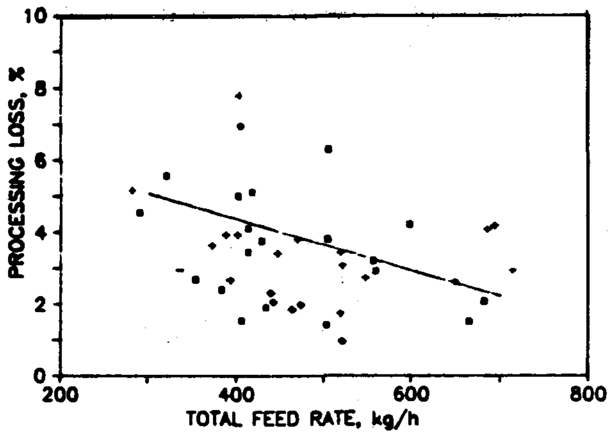
No difference would be expected unless the faster rotor speed further reduced the straw causing a different relationship among the MOG, grain and wind on the cleaning screen. A simple linear analysis regressing processing losses on total feed rate was run to sense changes occuring at different feed rates. Even though the measure of fit of the processing loss versus total feed rate was very low, the trend for the processing loss to decrease as total feed rate increased was evident.

This result is opposite to that expected. Usually in combines, an increase in feed rate results in an increase in the processing losses. Il is conceivable that, with larger feed rates, a thicker mat of material forming on the cleaning screen might have a tendency to retard the wind volume. Therefore, less grain would be discharged over the cleaning screen. This same reasoning would suggest that at larger feed rates, the MOG in the clean grain would be greater and this was not the case. Using 3% as an acceptable processing loss, approximately half of the samples were in excess of 3 % and half less than 3 %.

**Table II. Throughput determined by weighing the unthreshed material and the threshed grain for each test run**

| ID | Grain + MOG kg | Grain kg | MOG kg | MOG/G ratio | Rotor speed RPM |
|---|---|---|---|---|---|
| H0002 | 100 | 36 | 64 | 1.78 | 785 |
| H0003 | 148 | 63 | 85 | 1.35 | 785 |
| H0528 | 148 | 46 | 102 | 2.22 | 785 |
| H0628 | 95 | 33 | 62 | 1.88 | 785 |
| H0728 | 185 | 67 | 118 | 1.76 | 785 |
| H0830 | 144 | 52 | 92 | 1.77 | 843 |
| H0930 | 184 | 62 | 122 | 1.97 | 843 |
| H1030 | 97 | 33 | 64 | 1.94 | 843 |
| H1131 | 191 | 67 | 124 | 1.85 | 843 |
| H1231 | 190 | 74 | 116 | 1.57 | 785 |
| T0001 | 92 | 34 | 58 | 1.71 | 750 |
| T0004 | 128 | 44 | 84 | 1.91 | 750 |

ID beginning with H is test machine
ID beginning with T is comparison machine




Fiure n°1 : **total feed rate versus processing loss.**

Table III. **Average of respective samples of designated variables.**

| ID | MOG feed rate kg/h | Grain feed rate kg/h | Total feed rate kg/h | Processing losses % | Damaged grain % | MOG in grain % | MOG/G ratio |
|---|---|---|---|---|---|---|---|
| H0002 | 270 | 235 | 505 | 2.4 | 6.9 | 0.7 | 1.15 |
| H0003 | 344 | 166 | 510 | 3.8 | 6.7 | 1.9 | 2.25 |
| H0528 | 229 | 120 | 349 | 3.8 | 5.6 | 1.2 | 2.60 |
| H0628 | 222 | 167 | 389 | 2.3 | 4.4 | 1.3 | 1.35 |
| H0728 | 231 | 261 | 492 | 3.5 | 2.7 | 0.6 | 1.10 |
| H0830 | 220 | 144 | 364 | 3.9 | 15.8 | 2.1 | 1.56 |
| H0930 | 318 | 188 | 506 | 3.0 | 11.3 | 3.2 | 1.70 |
| H1030 | 251 | 174 | 425 | 3.2 | 16.7 | 3.6 | 1.43 |
| H1131 | 419 | 265 | 684 | 3.5 | 5.1 | 1.7 | 1.61 |
| H1231 | 296 | 208 | 504 | 4.4 | 4.9 | 0.7 | 1.52 |
| T0001 | --- | 276 | --- | 1.6 | 0.6 | 1.2 | ---- |
| T0004 | --- | 225 | --- | 2.0 | 1.7 | 0.3 | ---- |

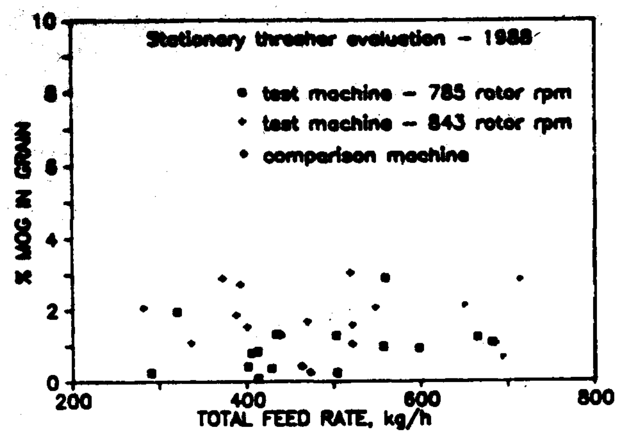
Comparison machine MOG rate, as measured by sampling, is not known because of the excessive straw in the tailings return.

With the comparison machine, processing losses were very acceptable. However, as previously mentioned, with the wind volume properly regulated to minimize processing losses, the return auger continued to plug with the excessive straw in the tailings. For this thresher, the 5 samples obtained from the comparison machine illustrate that the processing losses were all less than 3 %.
The importance of keeping processing losses at a level less than 3 % may not be critical. In many countries, straw is used as an animal feed, therefore, some grain in the straw would not be a loss.

Another measure of thresher capability is the cleanliness of the grain after threshing. Figure 2 illustrates the MOG in the clean grain as a percent of the weight of the total grain sample versus the total feed rate. A simple regression analysis indicated no trends in response of MOG in the clean grain to total feed rate for the test machine. Very small amounts of MOG were observed in the clean grain for the comparison machine, with all samples being less than 2 % of MOG in the grain. Irrespective of the feed rate, rotor speed or type of thresher, theMOG percentage in the clean grain was usually less than 3 %.

A measure of visible grain damage occurring during the threshing operations is the amount of cracked and crushed grain in the clean grain. At the higher threshing rotor speed of the test machine, 843 rpm, there is a definite relationship between damaged grain and total feed rate, figure 3. The results of a linear regression analysis indicated that the percent damaged grain is reduced by 3. 5 % for every 100 kg/h increase intotal feed rate. Therefore, the speed of the threshing rotor should be no faster than required to efficiently thresh the grain. One hypothesis might be that at low feed rates, the grain in the threshing area loses the cushioning effect due to the presence of the straw. As feed rate increases, the presence of larger amounts of straw

cushions the impact of the rotor spikes on the grain thereby reducing grain damage.




At the faster rotor speed, the necessity to keep the machine operating at full capacity is apparent. At the slower rotor speed, 784 rpm, there is also an advantage to keeping the machine operating at full capacity. Irrespective of rotor speed, these threshers, like combines, should be operated near capacity for best results.

The comparison machine caused very little damage to the grain, with all observations of damage being less than for the est machine. The reason for this is that the conventional combine, and the test machine functions more like a hammer mill.

Figure 2. **Total feed rate versus MOG in grain.**

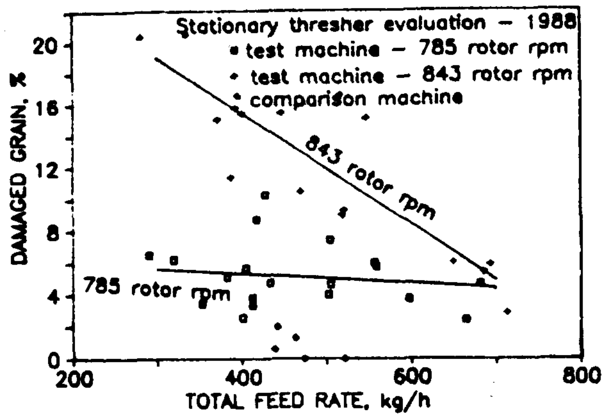



Figure 3. **Total feed rate versus damaged grain.**

## VI- CONCLUSIONS

The following conclusions can be made :

1- Both threshers can do an adequate job of threshing.

2- Total feed rates, estimated at 500 kg/h, were obtained with the comparison machine. Actual total feed rates, based on sampling, were not known because of excessive straw in the tailings return. Processing losses were less than 2 % and damaged grain was nil.

3- The comparison machine had a major problem with excessive straw in the tailings return at acceptable processing loss levels. This problem could probably be solved by a design change.

4- Total feed rates up to 700 kg/h were observed with the test machine with processing losses averaging less than 4 % . Damaged grain averaged less than 7 % at moderate threshing rotor speeds.

5- The test machine can cause excessive grain damage at fast threshing rotor speeds and small total feed rates. This machine functions best when operated near capacity.

6- A big advantage of the test machine is that straw is reduced during the threshing process. This makes the straw very desirable for animal feed.

7- As new varieties of cereals are developed, attention needs to be focussed on the effect of the straw on pneumatic separation.

## VII- OBSERVATIONS

1- The test machine is underpowered. The machine has more capacity than available power.

2- When testing these machines, it was very important for those persons involved with the actual test to have sufficient practice in material input and sampling. This results in a much smoother input of material and eliminates slugging the machine.

3- The collection of the MOG catches has to be accomplished without interfering with the wind volume and direction. If the catch devices are too restraining, alteration of machine performance occurs easily.

## VIII- ACKNOWLEDGEMENT

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# RESUME


Test de performance de batteuses à poste fixe.

Le battage pose encore un grand problème dans les régions où la moissonneuse batteuse n'a pas accès. Et il y a beaucoup de possibilités pour l'utilisation et le développement de petites batteuses à poste fixe pour les céréales et les légumineuses. Ces machines sont très simples à faire fonctionner et peuvent être très facilement appropriées quand la récolte est rassemblée sur les aires de battage.

Aupparavant, nous n'avons pu trouver une méthodologie pour tester ces batteuses. Ce qui nous a condui à utiliser la procédure de test des moissonneuses en la modifiant pour répondre à nos besoins. Ces méthodes sont disponibles dans ASAE (American Society.f Agricultural Engineers) et PAMI ( The Prairie Agricultural Machinery Institute).

Le but derrière ce test était de voir si la batteuse Hassouni (Ména modifié et fabriqué au Maroc) peut répondre à ce besoin et remplir cette fonction. Donc cette machine Hassouni a été considérée comme machine test et une autre machine Thaïlandaise, de même capacité, a été considérée comme témoin ou machine comparaison.

Les résultats ont montré que les deux machines pouvaient faire un bon travail si les réglages et les instructions sont bien respectés.