CEREAL GRAIN LOSSES FROM CUSTOM COMBINING OPERATIONS

G.E. MONROE*, O.G. MERKLE**, R.K. BANSAL*, and H. FARIHANE**

INTRODUCTION

There were 3324 combines for cereal grains in Morocco in 1989 (Amediaz, 1990). Many of the combines in Morocco are used for custom harvesting within the total cereal production area of about 4.6 million hectares (Enquete Agricole, 1987). Estimates of losses from various individuals for the worst of these custom harvesting operations, based largely on observations of subsequent volunteer crop, are up to 20%. However, no documented information has been found on the actual extent of these losses. There is some indication that the losses may be low. Bashford and Merkle (1990) did a brief survey of grain loss on the ground in 5-10 fields shortly after they were combined in 1990. Based on the seeds found per unit area of examined ground, they concluded that the losses were not excessive. The information they obtained did not allow them to calculate losses as a percentage of the pre-harvest crop yields.

* and** ; Agricultural Engineers and Agronomists, respectively, at the Institut National de la Recherche Agronomique in Settat, Morocco.

The primary objectives of this study were to :

1. Develop a simple procedure for determining the percentage of crop yields being lost from custom combining operations, and one that caused little or no disturbance to the combine operations.

2. Determine combine losses from several representative machines, fields and crop conditions.

3. Compare the losses with acceptable loss levels, using information in a standard of the American Society of Agricultural Engineers (ASAE).

4. Estimate the impact of any excessive losses on Moroccan grain production.

5. Determine what, if anything, needs to be done in the future to reduce custom combining losses.

PROCEDURES

ASAE Standard S399.2 (Americain Society of Agricultural Engineers, 1991) gives 1% and 3% for wheat and barley, respectively, as the processing loss levels for determining a maximum sustained feed rate (capacity) for a combine. These levels are essentially the maximum amounts of grain that can be lost through the combine, expressed as a percentage of the harvestable grain yield. The standard gives detailed procedures for evaluating combines. However, they require the attachment of apparatus to the combine to collect all of the effluent from the machine during a "catch" period. Since one our objectives was to survey losses from different combines, the apparatus would have to vary somewhat from one machine to another. Also, attaching it to the combines would disturb normal combining operations. For these reasons, a different procedure would have to be developed for determining combine grain losses in Morocco.

We developed an appropriate combine-loss procedure as we began observing combining operations around Settat. Some of the operations were in small fields which took only a few minutes for a combine to complete. At one location two combines were working together and quickly harvested a fairly large field. Combines moved rapidly in the fields when there was a medium to light crop and when the combine headers did not have to be operated close to the ground. For these reasons we realized that our sampling procedures in the field should not take much time.

Initially we took combine-loss samples by picking grain up from the ground after the combine had passed. However, it was very difficult to collect the losses from the ground because of all the chaff, irregular soil surfaces, and cracks in the ground. The procedure was further complicated when the combine operation included the common practice of collecting straw on a plywood board and then dumping it periodically`. During collection, the board was positioned horizontally about even with the bottom rim of the discharge hood. To dump the material, the board was released at the rear and pivoted down from front-mounted hinges, allowing the material to slide off the board as the machine moved forward. The large amount of material in the resulting pile, plus the fact that some combines did not collect all of the discharge on the board, made the sampling procedure very cumbersome and imprecise.

To alleviate these problems, we used another procedure for collecting the combine-loss samples. Two people carried a canvas to the combine as it was operating, with one person on each side of the discharge hood. The canvas was quickly unfolded, from the front to the rear of the discharge, and laid on the ground (stubble). This provided a convenient method for obtaining a representative sample from the area of the canvas length, front to rear, times the effective cutting width of the combine. Normal combining operations were not distrubed for operations with continuous straw discharge. For operations with periodic dumping of the straw, the operators were asked only to leave the dump board open long enough to allow sample collection onto the canvas. Our aim was to take three combine-loss samples for each combine. These samples were pre-processed on the canvas, by hand removal of straw and winnowing, to reduce the volume of samples taken to the laboratory for final processing.

We used 0.5 m2 sampling squares for the remainder of the samples collected Three samples were taken to determine harvestable yield before combining, and three ground samples were taken after harvest to obtain the combination of pre-harvest and cutterbar losses. All of these samples were fairly easy to collect. The yield samples required simply collecting all standing seed heads. The pre-harvest plus cutterbar ground losses were also primarily equipement for threshing, cleaning and weighing.

The field selection procedure was simply to travel by car until we saw a combining operation. We then entered the field, explained our objectives to the farmer, and asked if we could sample the harvesting operation. Upon receiving permission, we proceeded to collect the samples and other information. The other information included the location of the field; the combine make, model, cutterbar width and license number (to avoid sampling the same machine twice); the height of the standing crop, the cutting height of the header, and the speed of the combine in operation. Combine speeds were one representative measurement for the operation, and were not taken coincident with the combine-loss sampling.

RESULTS

All of the farmers and operators were willing to let us sample their combining operations, once the purpose of the survey and the sampling procedure were explained to them. The sorting and winnowing of the combine-loss samples on the canvas often resulted in a beneficial demonstration to the farmers and operators of the degree of combine losses.

The combine operations sampled for this study were all within 40km of Settat. The combines were from six different manufacturers, with several different models among them from one manufacturer. The cutterbar widths ranged from 3.5 to 4.8m, with most of them 4.2m. Only three operations were sampled in barley fields. None of them exceeded the 3% maximum loss, although one was close at 2.5%. Among all the wheat and barley operations sampled, there was no correlation between losses through the machines (combine losses) and combine make, speed, or cutting height. We observed that, in general, the combine operators adjusted the combine speed and cutting height correctly for the crop and field conditions. Field sizes, based on estimates, ranged from 2 to 20 ha. There also was no apparent correlation between field size and combines losses.

The yield and loss results from 16 combines (operations), including 5 in soft wheat and 11 in hard wheat fields, are shown in Table 1. The harvestable yield estimates shown in the left column do not include the pre-harvest and cutterbar losses. All loss figures are percentages of the harvestable yields. Two combines were used in the same field in two of the fields. Loss data is presented for each sample replication in order to show the number of samples and the degree of variability among samples for each operation. The table is divided into two sections to distinguish between combines with losses below the maximum of 1% and those with losses above 1%.

There was little variation among the three samples collected for each yield estimate, so these figures are probably reasonably accurate. We were not always able to gather the three samples that we wanted for losses. This was especially true for the combine losses, which were the most difficult to obtain. Also, there was often, more variation between loss samples for an operation than between operations. This may have been due to real differences in the instantaneous combining results sampled, and/or to a change in the operations during the sampling period.

The overall pre-harvest plus cutterbar losses were more severe than the combine losses. They averaged 2.6% for all operations, ranging from 0 to 7%. Some of these losses were due to Hessian fly damage, and some were probably due to birds. However, a large portion of the high-percentage losses probably occurred because of the overripe condition observed in almost all of the fields sampled, indicating that combining should have been done earlier to minimize losses.

The averages indicate a 2% greater combine loss from the 8 operations with losses above 1% than from the 8 operations that were below 1%. The question arises as to what confidence we have in these numbers. We may be able to say with 90% certainly that the mean combine loss for all operations is between about 1% and 2%. This can be calculated by using either the averages from all 16 operations, or considering each of the 38 samples as from a different operation.

The average total of pre-harvest, cutterbar and combine losses was over 4% for both the above and below 1% categories of combine loss. They ranged from 1.7 to 7.5% and from 48 to 174 kg/ha. In any case, even the highest total losses were certainly less than had been estimated by some. However, a study of the data in Table 1 suggests a reason for high estimates based on high post-harvest volunteer plant populations. The pre-harvest plus cutterbar loss of 6.4% in the field with a 2560 kg/ha yield would provide an effective uniform seeding rate of about 165 kg/ha, or about 400 seeds/m2. The combine loss of 3% in the field with a 4550 kg/ha yield would concentrate into an effective seeding rate of over 400 kg/ha, or about 1000 seeds/m2, within the combine discharge strips that were about 1/3 the width of the combine cutterbar. The resulting thick plant stands could suggest percentage losses higher than actual losses.

Little information could be obtained about machine problems that would contribute to unnecessary, or excess, combine losses. This was because most of the machines were always in operation while we were in the field. In one case we observed a dense buildup of material on the straw racks of a stopped combine. The operator quickly cleaned the material out after we brought the problem to his attention. In general, the combine operators seemed to be aware of the effect of combine speed on combine losses.

Table I : **Crop yield; pre-harvest plus cutterbar loss, combine loss, and total loss for wheat operations. Operations with less than 1% combine loss:**

Yield Wheat		% P H + C B Loss		% Combine Loss		Total
Kg/ha	Type	Reps	Ave	Reps	Ave	loss
2670	H	2.0, 3.0, 0.6	1.9	0.4, 0.2, 1.6	0.7	2.6
670	H	9.5, 4.5	7.0	0.1	0.1	7.1
5240	H	3.6, 0.5, 0.4	1.5	1.1, 0.6, 0.2	0.6	2.1
3400	S	0.4, 2.2	1.3	0.4	0.4	1.7
1290	H	4.7, 4.8, 2.6	4.0	0.5, 0.3 0.3	0.4	4.4
2070	S	5.6, 4.8, 4.8	5.1	0.2, 0.2, 0.7	0.4	5.5
2560	S	9.5, 7.6, 2.2	6.4	0.4, 0.2, 0.7	0.4	6.8
1840	H	2.8, 6.8, 0.0, 0.0	2.4	1.3, 0.2	0.8	3.2
		Ave	3.7		0.5	4.2
Operations with more than 1% combine loss :						
3020	H	0.0, 0.0	0.0	1.7, 1.7	1.7	1.7
2670	H	2.0, 3.0, 0.6	1.9	1.1, 1.3	1.2	3.1
4550	H	0.6, 0.2, 0.0, 0.0	0.2	7.7, 1.0, 2.5, 0.6	3.0	3.2
1260	H	3.7, 3.9	3.8	1.2, 6.2	3.7	7.5
2490	H	0.4, 6.0, 2.6	3.0	8.0, 0.1, 0.1	2.7	5.7
3110	S	0.6, 1.1, 0.4	0.7	5.7, 1.2	3.5	4.2
3110	S	1.0, 0.0, 0.6	0.5	2.2, 3.3	2.8	3.3
2220	H	4.1, 1.3, 2.3	2.6	0.9, 2.0	1.5	4.1
		Ave	1.6		2.5	4.1
		Grand Mean	2.6		1.5	4.1

P H = pre-harvest, C B = cutterbar, H and S = hard and soft wheat

POSSIBLE ECONOMIC EFFECTS

At first glance, the mean combine loss of 1.5% for all of the wheat operations sampled does not seem serious. However, comparing it with the 0.5% average loss that was achieved with the better half of the operations sampled may indicate a significant economic cost when applied to the national wheat production in Morocco.

There are many ways to estimate the possible economic effect of national combine losses based on the results of our samples. We have tried to select the most reasonable methods, using the best and most current information available. The factors needed for multiplication in the equation we used were:

1- The number of hectares of wheat combined in 1991.

2- The average estimated 1991 wheat yield per hectare.

3- The estimated percentage of excess combine loss.

4- The average 1991 value per kg for wheat.

We calculated factor 1 by first increasing the 3324 combines in 1989 by 200, following the linear rate of increase for the previous 4 years, and allowing an annual usage rate of 450 hectares per combine (Amediaz, 1990). The resulting 1,585,800 hectares was then reduced by 50% according to the ratio of wheat to barley hectares in 1987 (Enquete Agricole, 1987). This gave us 792,900 hectares for factor 1.

We used the average yield of 2600 kg/ha from the wheat fields we sampled for factor 2. We used the difference between the average combine loss of 1.5% for all the operations we sampled and the average 0.5% achieved from the better operations, or 1%, for factor 3. And finally, we used 2.5 dirhams per kg as the average price for wheat for factor 4, based on our own survey of 1991 prices. Multiplication of the first three factors gave us an estimated national excess crop loss from wheat combining in 1991 of 20,615 tonnes. Similarly, multiplication of all four factors gave us a national excess loss value of about 50 million dirhams.

No credit to discretionary income loss was given for the animal grazing value of volunteer crop from excess combine losses. This was because there would still remain a 3.6% field loss after subtracting the 0.5% achievable combine loss from the overall total loss of 4.1%. This would provide an average seeding rate of about 94 kg/ha based on the 2600 kg/ha average yield of the wheat fields we sampled. This should be sufficient. In fact, it would be desirable to reduce the pre-harvest and cutterbar losses if possible. These losses could be a hindrance to subsequent planting in areas where annual wheat is practiced and animals do not graze the fields.

CONCLUSIONS

1- More sampling is needed on barley operations to evaluate the extent of those losses.

2- The procedures developed were effective for the required timely gathering of samples in the field and without unduly disturbing the combining operations. This includes the canvas-collection method for determining combine losses. However, there were wide variations among combine loss samples for some operations, indicating perhaps a reason why ASAE Standard S396.2 describes a much more complex procedure. An improvement over the canvas collection method we used would be desirable, but one like S396.2 would not be practical for the type of survey we did.

3- The visual demonstration of combine losses to the farmers and operators, through the on-site processing of the samples, served a beneficial educational purpose.

4- The wide variations in combine losses among samples for some operations, along with the limited number of samples, limits the certainty of predictions for national economic losses. However, there are two arguments supporting the use of the 1% excess loss amount. One is that in at least one case the initial combine-loss sample of an operation gave a much higher loss than subsequent samples for the same operation. This suggests the possibility that the visual demonstration of a high loss may have resulted in a change in the operation, such as a reduction of combine speed, that reduced subsequent losses. Another argument is that the actual losses would likely average higher than our samples indicate. This is because some loss was probably thrown out during the on-site processing of the canvas-collected samples.

5- An improved sampling procedure and the sampling of many more operations would be required for a higher degree of certainty in predicting the national value of excess losses.

6- Sample data should be gathered in a way that will provide a breakdown between pre-harvest and cutterbar losses, to assist in determining if harvest was timely or too late to minimize losses.

Late harvest could certainly be a major contributor to high pre-harvest losses. However, a large part of cutterbar losses could also be caused by late harvest, due to the breakage of overripe heads by the normal operation of the cutterbar reel.

7- The possible national excess combine loss value in 1991 of 50 million dirhams for wheat alone is significant enough to warrant attention to improved combine maintenance and operation. However, reduction of pre-harvest and cutterbar losses through better timing of harvesting could have an equal or perhaps greater impact on Moroccan grain production.

8- The value of excess combine losses should be balanced against any increased costs, such as combining cost per hectare, that might be associated with the reduction of those losses.

AKNOWLEDGEMENTS

Support for this study was received from the United States Agency for International Development Project N°608-0136.

The authors also wish to express appreciation to Dr. David Keith, Team Leader, MidAmerica International Agricultural Consortium, and Dr. Mohamed El Mourid, Director, Centre Regional de la Recherche Agronomique, Settat, for their strong interest and support in this study.

ABSTRACT

Procedures were developed for rapidly obtaining field samples to calculate grain losses. The procedures caused minimal disturbance to the combine operators. Sample data were generally satisfactory, except for wide variations among samples of combine losses through some machines. There were insufficient operations sampled to draw any conclusions about barley combine losses. The overall total average loss for wheat operations was 4.1%, with 2.6% from pre-harvest and cutterbar losses and 1.5% from combine losses through the machines. Half of the 16 combines sampled in wheat operations achieved combine losses under 1% and averaging 0.5%, and the other half had losses over 1% and averaging 2.5%. Based on our sampling and an overall average combine loss 1% greater than necessary, the 1991 national cost of wheat excess combine losses was estimated at about 50 million dirhams.

RESUME

Des procédures ont été développées pour l'obtention rapide d'échantillons dans les champs afin d'estimer les pertes de rendements-grain. Ces dernières n'ont pas beaucoup gêné les opérateurs des moissonneuses-batteuses. La procédure d'échantillonage utilisée paraît satisfaisante. Cependant, les variations entre les échantillons obtenus d'une même moissoneuse-batteuse sont assez importantes. Le nombre d'échantillons utilisés n'était pas assez élevé pour permettre de tirer des conclusions relatives aux pertes de rendement pour l'orge. Les pertes globales pour le blé étaient en moyenne de l'ordre de 4.1% avec 2.6% dus à la pré-récolte et à la barre de coupe, et 1.5% dû aux réglages des moissonneuses-batteuses. Huit moissonneuses sur les seize testées pour le blé ont enregistré des pertes de moins de 1% qui est la valeur généralement acceptable. Le coût national des pertes de rendement du blé occasionné par l'utilisation des moissonneuses-batteuses a été estimé à environ 50 millions de dirhams en 1991.

ملخص

لقد تم تطويرطرق سريعة تمكن من الحصول على عينات حقلية لتقديرخسائرالمردود الناجمة عن استعمال آليات الحصائد أو الضم والدراس. هذه الطرق لا تشكل اضطرابا كبيرا في عملية الحصاد.

إن طريقة المعاينة المتبعة كانت جد إيجابية، لكن التباين بين العينات المحصل عليها من خلال آلة حصاد واحدة كان كبيرا. أضف إلى ذلك أن عدد العينات المستعملة لم تكن كافية للوصول إلى خلاصات بشأن خسائرالمردود عند الشعير. عموما كان معدل الخسارة عند القمح يناهز 4.1٪ منها 2.6 ٪ تعزى إلى خسائرما قبل الحصاد وإلى مشط الحصد، في حين ترجع 1.5٪ إلى معايرة آليات الحصاد. بالإضافة إلى هذا، تبين من خلال هذه الدراسة أن ثمانية (8) آليات حصاد من بين ستة عشرة (16) سجلت خسائرأقل من 1٪ أي النسبة المقبولة عموما في ميدان المكننة الفلاحية، في الوقت الذي سجلت فيه الثمانية آليات الأخرى خسارة أكثر من 1٪ وبمعدل 2.5 ٪ من المردود المحصل عليه.

وبناء على المعطيات التي تم استخلاصها من خلال هذا البحث، يمكن تقديرالخسارة الإجمالية الناجمة عن استعمال آليات الحصاد على الصعيد الوطني بحوالي خمسين مليون درهم عن سنة 1991.

REFERENCES BIBLIOGRAPHIQUES

AMEDIAZ, R. 1990. Moyens de mecanisation actuels des operations culturales : cas des cereales d'automne. Institut Agronomique et Veterinaire Hassan II, depertement de Machinisme Agricole.

American Society of Agricultural Engineers, 1991. Combine capacity and performance test procedures. ASAE Standard S396.2. In ASAE Yearbook. ASAE, St. Joseph, MI 49085.

BASHFORD, L. L. and MERKLE O. G. 1990. Personal communication. Centre Regional de la Recherche Agronomique, Settat, Morocco.

Enquête Agricole. 1987. Direction de Statistique, Service de Statistique et Documentation, Ministère d'Agriculture et Réforme Agraire, Rabat.