Crop Cutting versus Farmer Reports - Review of Swedish Findings

Lars Hagblad

Statistics Sweden

ABSTRACT: In 1960, Statistics Sweden introduced objective crop-yield surveys to determine the size of the harvested yield. The method is called "objective" because the figures returned are based on the measurement and weighing of samples which are taken using statistical sampling methods. This crop-cutting included cereals, potatoes and ley for hay and silage.

Budget constraints and less need for accurate and detailed statistics led to a review of the scope and methods. It was intended to substitute the objective crop-yield surveys with crop-yield data collected directly from the farmers. Pilot studies were performed to find out the quality of farmers' reports compared with the Objective Crop-Yield Surveys. Results and conclusions from these studies are presented in this report.

Farmers' reports by mail enquiry gave unreliable estimates compared with the Objective Crop-Yield Surveys, especially for potatoes and ley. For these crops, the objective method is still considered to be the most practicable procedure. For grain crops, it was decided to test interviews with farmers as an alternative method. This approach led to more reliable estimates, even if not fully satisfactory. The "interview" method was introduced in 1998 for the official Swedish crop-yield statistics for grain crops.

1. Introduction

Crop-yield statistics are collected in many different ways: interviews with farmers, mail enquiries to farmers, estimates by agricultural experts, but also more objective methods like crop-cutting and weighing of samples. Methods based on crop-yield simulation models and remote sensing will also become increasingly interesting. Data collection methods also differ for various crops in a country depending on the conditions and possibilities, and often a combination of different methods is used. Internationally, objective yield surveys with crop-cutting are undertaken in some countries, one of which is Sweden. In other EC countries, crop-yield data are usually collected by farmers' reports through mail enquiries.

The oldest yield data for Sweden can be traced back to the 18th century. Yield data from this period were based on a general assessment of all types of cereals. These subjective estimates became modified as time progressed but were still the basis of our crop-yield statistics up to the 1960s. During the Second World War, the crop-yield statistics became increasingly more important since they provided a basis for food rationing. The subjective crop-yield estimates were found to be less dependable, especially in years with large deviations from normal yields. This led to demands for more reliable crop-yield surveys.

Objective Crop-Yield Surveys (OCYS) were introduced in Sweden in 1960 for producing the official crop-yield statistics. They were designed after a series of experiments and pilot surveys, and have been continuously improved. The method is called "objective" because it is based on probability sampling and physical measurements with samples being taken in the fields. Grain crops, potatoes and ley for hay and silage have been included in the OCYS.

The OCYS were very comprehensive for a long period. Scope and coverage of the survey programme were dimensioned to supply crop-yield data for the Government Crop Insurance System. Within this frame, other needs for yield data were covered. Their scope and coverage has been greatly reduced

since 1989, mainly for budget reasons, but also because of the decreased need of accurate and detailed statistics for the Crop Insurance System, which was also terminated in 1994.

In 1991, for reasons of economy, the Government assigned Statistics Sweden to make a thorough review of the scope and methods for Swedish yield statistics. A new system was launched in 1995. It was based on a combination of farmers' reports and objective crop-yield surveys. Further budget constraints led to a changed approach for 1998. The OCYS are practised for potato crops only. Farmers' post-harvest estimates, collected by interviews, are now the main method for grain crops. Comparisons between results from different methods have been made both before the OCYS were introduced, during the time they were performed, and when the method began to get phased out. Some of this material and of these findings are described in this report.

2. The Objective Crop-Yield Surveys

For almost 40 years, Swedish crop-yield statistics have been based on nationwide objective crop-yield surveys of the following major crops: winter wheat, winter rye, spring wheat, barley, oats, ley for hay or silage (including re-growth) and potatoes. Thus, there are unique possibilities to compare farmers' estimates with the OCYS which are supposed to give unbiased results.

2.1 Measurement Procedures

Sample plots are cut/dug prior to the farmer's harvest. The shape, size and location of the sample plots were thoroughly tested before the OCYS method was introduced. It was decided that for grain and ley samples, plots of 1.0 square metre would be sufficient, that circular sample plots would be appropriate, and that the variation within the field requires at least two sample plots per field. In fields under potatoes, the sample plots are 2.0 metres of a row.

The ley and grain samples are sent to the laboratory of Statistics Sweden, where they are threshed/chopped, dried to zero percent water content and weighed. The potato samples are weighed in the field, the weights are entered on forms and sent to Statistics Sweden. Certain complementary information is also obtained, e.g. unharvested area.

The OCYS can deliver accurate preliminary results fairly early, before the farmers' harvests are completed. For grain, a system of sampling adapted to ripeness is used. This implies that the sampling must be started as soon as the crop has reached "binder ripeness", which normally occurs 2-3 weeks before the farmers' harvesting. At this stage of ripeness, the assimilation in the grain has been completed. However, this sampling adapted to the ripeness of the plots is not applied if there is a risk that the yield will substantially decrease during the period up to harvesting. Also, for potatoes and ley crops, certain rules are applied for early harvesting of the sample plots. Thus, timeliness is an advantage for the OCYS method.

2.2 Sampling Procedures

For sampling to estimate yields per hectare and total yield, area data from the Farm Register of Statistics Sweden have been used since 1970. The Register covers all holdings with more than 2.0 hectares of arable land. It is updated yearly, but since 1996 there is registration of crop areas only for a sample of farms. The non-response is very low and the quality of figures given is good, which is also confirmed through annual field checks at a sample of farms.

Since 1988, the sample for the OCYS for cereals and ley includes holdings with more than 5 hectares only. A multistage design has been used with a systematic PPS sample of holdings and fields. The sample plots are selected at random in the fields. The sample for potatoes has a similar multistage design and a random selection of sample plots in the fields.

2.3 The Field Staff

Fieldwork is conducted by enumerators employed all over the country at the County Boards. These enumerators operate under instructions according to a detailed manual and supervision of the County Boards. Most of the enumerators have agricultural experience. Training includes annual courses, and the enumerators are also visited randomly by the supervisors and Statistics Sweden staff to ensure that work is in concord with the instructions.

3. Pilot Studies

A number of pilot studies were performed during 1991-1997 with the aim to develop methods for collecting yield data directly from the farmers. Farmers' estimates were supposed to be a possible way to get less expensive crop-yield statistics than those obtained through the Objective Crop-Yield Surveys, although less reliable. A combination of OCYS and farmers' reports could perhaps also be a practicable approach.

3.1 The 1991 Study — mail enquiries to farmers in five counties

In 1991, mail questionnaires were sent to a PPS sample of about 3 000 farms in five of the 24 counties. The sample was drawn from the Farm Register in the same way as the first stage of the sample for the objective crop-yield survey. It was independent of the ongoing OCYS. The enquiry covered five cereal crops and first cut of ley.

The results for cereals were rather promising. There were no significant differences for the five counties when the two methods were compared and no tendency of bias in the estimates of crop-yield per hectare. On the other hand, the results for ley (first cut only) proved unacceptable, with significant under-estimates of about 20 percent. 1991 was a fairly normal year from an agricultural point of view. Statistics Sweden claimed that test enquiries should be undertaken over several years, hopefully including some non-normal years, in order to be able to draw reliable conclusions.

3.2 The 1992 Study — mail enquiries to farmers in five counties

This study covered the same five counties as in 1991. Approximately the same approach was applied in the 1992 pilot survey. The questionnaire was, however, much improved and potato yields were also included.

3.2.1 Execution

About one month before the harvest, an introductory letter was sent to the farmers and in mid-October when most harvesting was completed, new letters and the questionnaires were mailed. Areas of the actual crops according to the 1992 Farm Register were preprinted on the questionnaires. From evaluation studies in the Farm Register, it is known that the net sown areas for cereal crops and ley are 2-4 percent (and up to 10 percent for certain crops and regions) less than reported to the Farm Register. This means that estimates of yields per hectare according to the mail enquiry (when based on total yield

divided by acreage) will be somewhat lower than those of the objective crop-yield surveys, where the yields are based on actual net sown areas. In order to make materials comparable, the estimates of crop areas of the mail enquiry were reduced by the relevant conversion factors. For potatoes, a corresponding conversion was made. Thus, discrepancies in area definitions were taken into account.

3.2.2 Results

The growing season of 1992 happened to be extremely dry up to mid-July. The drought seriously affected major parts of Southern and Western Sweden. The results of the mail enquiry were obviously influenced by this fact and were generally much lower than those of the objective crop-yield survey. In many cases, the deviations were remarkable and often statistically significant. However, the differences varied substantially and they were not unambiguous. In a few cases, the mail enquiry even showed significantly higher yields than the OCYS. There was no evident pattern in the differences.

Table 1 shows that, on an average based on the entire material, the differences were extremely high for ley and potatoes, -19 percent in both cases. As for cereals, the average differences were smaller, varying from about -2 percent for winter rye to -8 percent both for winter and spring wheat. Looking at the maximum differences at the county level, these were surprisingly high. In the case of oats, the maximum yield differences went in the opposite (plus) direction, i.e. the mail enquiry overestimated the yields.

Table 1. Yields according to the Objective Crop-Yield Survey (OCYS) and Mail Enquiry in 1992
Material from five counties pooled together

Crop	Yield according to:		Average difference	Maximum difference at county level
	OCYS	Mail enquiry		
	kg/ha	kg/ha	percent	percent
Winter wheat	5 760	5 290	-8.1	-10
Spring wheat	3 400	3 130	-7.9	-20
Winter rye	4 190	4 120	-1.8	-24
Barley	3 040	2 910	-4.2	-14
Oats	2 480	2 410	-2.8	+49
Ley for hay or silage (first cut)	3 800	3 090	-18.6	-38
Table potatoes	37 100	29 960	-19.3	-20

Conclusions from the 1991 and 1992 pilot enquiries:

- Statistics on crop-yields for ley and potatoes, both major crops in Sweden, cannot be based on mail enquiries.
- In situations with extreme crop conditions, like 1992, when statistical information is most important, it is not advisable to use mail enquiries to farmers as the only method for collecting data on crop-yields of cereals.
- The objective crop-yield surveys should be maintained also for cereals, at least on a small-scale basis, to provide data for combining with other less reliable crop-yield data, but also for "control and calibration" of weather-dependent crop-yield simulation models and from remote sensing applications.

- The results presented were valid at high-level aggregation. Broken down to counties and yield districts, differences were more frequent and larger.

3.3 The 1993 Study — post-harvest interview by visits to farmers

As a consequence of the discouraging results in 1992, it was concluded that further studies were required in order to find acceptable methods for collecting crop-yield data under less expensive procedures. So a decision was made to test interviews with farmers as an alternative method.

The interviewers, officials from the County Boards, visited the selected farmers in September-November, when harvest work was finished and the farmers had also received statements on delivered quantities. The sample was about 2,000 farms. Conducting interviews through visiting enabled measurements of water contents, volume weights, stored quantities, etc., which would improve the quality of the estimates. Basic data such as receipts on deliveries were used when available.

The interviewers were also allowed to perform the interview by telephone. This was used for small farms and also for farmers expected to be able to give accurate information. As many as 40 percent were telephone interviews.

Table 2. Yields according to the Objective Crop-Yield Survey (OCYS) compared with results from the Pilot Interview Survey in 1993 The whole of Sweden

Crop	OCYS		Interviews	
	Yield	Number of farms	Deviation from OCYS	Number of farms
	kg/ha		percent	
Winter wheat	5 990	1 760	-2.7	863
Spring wheat	5 140	451	+0.6	235
Winter rye	5 170	761	-0.1	383
Barley	4 350	2 421	+0.7	1 178
Oats	4 380	2 197	+6.0	1 072

As can be seen in Table 2, there was no tendency of underestimating yields as in the 1992 mail enquiry. The deviations ranged from -2.7 percent for winter wheat to +6.0 percent for oats. These figures relate to national level.

Conclusions from the 1993 pilot studies:

- In this more “normal” year, from an agricultural point of view, the interview pilot survey did not underestimate the yield as in 1992.
- The interviewing process became more extended than expected. Preliminary results were not available until the beginning of December.
- It would be necessary to make the instructions more detailed and precise for the interviewers and to standardise the procedure in order to improve the accuracy of the measurements and the timeliness of the statistics.

3.4 The 1994 Study — post-harvest interview by visits to farmers

During 1994, a post-harvest pilot survey of the same scope and range as in 1993 was performed, but with improved instructions. Telephone interviews were also performed to some extent. The results are shown in Table 3.

Table 3. Yields and Differences between the Objective Crop-Yield Estimates (OCYS) and Farmers' Estimates in 1994 The whole of Sweden

Crop	OCYS		Interviews		Difference	
	Yield	Number of farms	Yield	Number of farms		
	kg/ha		kg/ha		kg/ha	percent
Winter wheat	5 700	1 468	5 460	725	-240	-4.2
Spring wheat	4 440	532	4 460	253	-20	+0.3
Rye	4 610	660	4 760	328	+150	+3.2
Barley	3 780	2 585	3 790	1 223	+10	+0.3
Oats	3 090	2 281	3 200	1 087	+110	+3.4

At the country level, the differences between farmers' estimates and OCYS varied from -4.2 percent for winter wheat to +3.2 for rye and +3.4 percent for oats. For spring wheat and barley, the differences were less than 1 percent. For counties, the differences, of course, varied much more, for instance +24 percent for rye for the county of Gotland and -17 percent for winter wheat for the county of Stockholm.

4. Crop-Yield Surveys 1995-1997

After the review in 1991-1994 of the Swedish crop-yield statistics, a decision was made to change the methods. The main method for collecting yield data on cereal crops was decided to be interviews with farmers in a nationwide sample survey. Objective yield surveys were proposed to be maintained as the basic method for potatoes and ley for hay and silage. For cereal crops, the objective method was applied in parallel with the interview method in a sample of 32 out of 102 yield districts covering the whole country, except for the mountain range. This parallel approach made it possible to continue the comparison between the different methods as shown in Table 4.

Table 4. Differences between Estimates based on Farmers' Reports and Objective Yield Estimates, as percent of the Objective Estimates At country level, except for 1992, which includes 5 counties only

Crop	By mail	By interview				
	1992	1993	1994	1995	1996	1997
Winter wheat	-8.1	-2.7	-4.2	-2.2	+2.7	-1.0
Spring wheat	-7.9	+0.6	+0.3	+3.7	+2.6	+2.4
Rye	-1.8	-0.1	+3.2	+0.4	-1.0	-3.3
Winter barley	-	-	-	-1.2	+9.1	-4.9
Spring barley	-4.2	+0.7	+0.3	+2.1	+2.0	+1.8
Oats	-2.8	+6.0	+3.4	+6.1	+9.5	+7.1
Triticale	-	-	-	+9.0	-5.2	+5.0
Potatoes	-19	-	-	-	-	-
Ley for hay and silage	-19	-	-	-	-	-

Conclusions:

- 1992 was a very special year with extreme crop conditions, but our conclusion was (also after experiences from 1991) that it is not advisable to use mail enquiries to farmers as the only method for collecting data on crop-yields for cereals.
- Statistics on crop-yields for ley and potatoes could not be based on mail enquiries.
- Apart from 1992, there were ambiguous results for the cereal crops. At the country level, winter wheat seemed to be underestimated by the farmers, whereas spring cereals were overestimated, but there were no stable patterns for the various crops.
- When statistics were broken down to regional levels, for example to counties or yield districts, significant differences were more frequent and larger than those shown in the table.
- Calibration methods could not be easily found for transforming the farmer's estimate to an objective level.
- It has not been possible to evaluate the material regarding differences in results between interviews by visits or by telephone.

5. Discussion of Quality Aspects

5.1 General Evaluation of Objective Yield Estimates

The objective measurements approach ensures high quality estimates. We assume that estimates are approximately unbiased. The sampling errors are, of course, inevitable but are fairly small compared with systematic errors we have found in our comparisons with other approaches. The OCYS are the rationale of checking other estimates.

5.2 Sampling Errors

Sampling is a crucial source of errors, irrespective of objective or subjective methods. Given the same sample size of holdings, the sampling errors of objective yield surveys are larger than those of the farmers' estimates presented. The reason is that the sampling errors of the former, because of a multistage design, comprise more variance components. The significance analysis of the present results takes into account the sampling variation of both data sources. Several differences have turned out to be significant.

5.3 Non-response Effects

Non-response, of course, varies between the different methods for collecting yield data. For the 1991 mail survey, the non-response rate was 20 percent and in 1992, with the help of ample reminders, it was reduced to 5 percent. For the interview surveys (by phone or visits) in the following years, it ranged from 5 to 10 percent, but for the Objective Crop-Yield Surveys generally only 1-3 percent. The low non-response for the OCYS also confirms high survey quality.

Some of the enquiry material has been analysed with respect to varying non-response rates on the crop-yield district level. No clear correlation between size of difference of estimates and size of non-response rate was found.

5.4 Measurements Errors

It is assumed that the crop-cutting method gives estimates of yields that are unbiased in the sense that there is no systematic measurement error worth mentioning. Consequently, systematic differences between the objective and subjective yield estimates are interpreted as an effect of systematic measurement errors in the subjective yield estimates.

5.4.1 The Objective Crop-Yield Surveys

For cereals, the harvested yield is calculated by reducing harvesting losses and unharvested area from the first estimated biological "sample plot yield". Corrections for harvesting losses are made by using standard values calculated on the basis of previous surveys. These values are between 2.9 and 4.2 percent, depending on crop and part of Sweden. Unharvested area is collected by the enumerators and used for estimating the definitive statistics. Yield figures are presented at standard moisture content. The OCYS eliminates the difficulties with water contents which occur in other yield estimation methods. Grain quality and post-harvest losses are not considered.

The samples are processed at the Laboratory of Statistics Sweden. Regular checks are made, e.g. that no kernels are lost when threshing and cleansing the grain samples, that water content is zero percent (dry matter) when weighing, and that the scale is giving the correct weights. Possible errors are judged to be negligible.

Ley samples are treated in a similar fashion. In the calculations, corrections are made for growth between the day of cutting the sub-plot and the day when the farmer harvests the field. Corrections are also made for harvesting losses and for unharvested area. Harvested yield is calculated at a standard moisture content.

Samples of potatoes are taken by the enumerator before plants are lifted by the farmer. The enumerator weighs the yield of the potato sample plot. Subsequently, green tubers, tubers showing signs of decay, and small tubers are removed and weighed. The weights are recorded on forms that are sent to Statistics Sweden for data processing in October. Unharvested areas are later collected in order to complement the processing of the final statistics. Post-harvest losses are not regarded.

5.4.2 Farmers' (Post-Harvest) Reports by Interview

Conclusions after the 1991 and 1992 pilot surveys with mail enquiries to the farmers were that this approach could not be used for potatoes and ley for hay and silage and that the Objective Crop-Yield Surveys should be applied to these crops. For potatoes, it cannot be ignored that yield figures (farmers' estimates) have a great influence on the price. This might be an explanation of the underestimates when compared with the OCYS. Concerning ley, there are several measurement problems like the appropriate size of bales, water content, volume weights, etc. Furthermore, many farmers do not really know the quantities of ley they have harvested, but they certainly know that their harvests are large enough for feeding their cattle through the winter season.

For grain crops, mail enquiries gave too unreliable results when crop conditions were extreme, as in 1992. Interviews with farmers were tested and found to give more reliable yield estimates, which led to their further development and introduction as the main method for cereal statistics in 1995.

Measurement error components in the post-harvest interview survey for grain crops:

- Farmers do not always know the net sown area of crops. Errors may occur when they give yield figures in kg/ha based on total yield divided by acreage.
- Farmers have difficulties to recall current data.
- Farmers make rough estimates for quantities in barns and silos.
- Farmers' estimates are biased because of poor information on water content and bulk density.

5.5 Timeliness

Statistics based on farmers' post-harvest reports will, of course, be late. It is necessary to have all crops harvested (or definitely judged to remain unharvested) before reporting is possible. If documents on deliveries of crops are used as the base for reporting, even this may extend the reporting time. Different harvesting times in different parts of the country will, of course, also affect deadlines for reporting. Compared with the OCYS, statistics based on farmers' post-harvest reports will delay publishing by 2-3 months.

6. Cost Aspects

The observations and measurements of the objective crop-yield surveys are usually costly. They require much traveling and work in the fields, as well as comprehensive efforts for training and supervision of staff, maintaining equipment and processing at laboratories.

Table 5. Budgets for the Crop-Yield Surveys, million SEK

1961	1971	1981	1986	1989	1994	1995	1996	1997	1998
3	7	20	28	17	15	10	9	9	5

Table 5 shows that costs of the surveys substantially increased during the period it was built up, to about SEK 28 million in 1986. In 1989, the funding was substantially reduced to SEK 17 million as a consequence of the changed Crop Insurance Scheme. Further heavy reductions followed. In 1991, pilot studies with farmers' reports started, and in 1995-1997, farmers' reports by interview, in combination with reduced OCYS, became the main method for crop-yield statistics. For 1998, the Objective Crop-Yield Surveys will be kept for potatoes only and farmers' reports by interview will be the established method for the official grain crop-yield statistics. The costs are substantially reduced.

For administration and supervision of the enumerators, there is an additional cost of about SEK 3 million per year for the County Boards.

7. Concluding Comments

Objective yield measurements have now been applied in Sweden on a regular basis for almost 40 years. The technique has turned out to give most accurate as well as timely estimates of actual yields of the major crops. Methods and techniques have been thoroughly tested and developed for the Swedish context. Numerous improvements and changes have been made over the years in order to adapt the surveys to changing needs for statistics, to changing conditions, as well as budget constraints.

High costs for the field work, but also reduced demand for quality of results and breaking down statistics to regional level, have led to changes in methods for the crop-yield statistics. For 1998, the

Objective Crop-Yield Surveys are retained only for potato crops. For grain crops, interviews with a sample of about 4,200 farmers (5 percent) will be made.

From a quality point of view, the introduced post-harvest interview method is less reliable than the OCYS, especially when broken down to regional levels, but is still supposed to be satisfactory at the country level for grain crops.

For potatoes and ley for hay and silage, the post-harvest interview method has appeared to be too unreliable. No alternative measurement method seems to be feasible so far. For potatoes, the OCYS will be kept, at least for 1998, and for ley, decisions on future methodology have not yet been made (February 1998).

Swedish users of the official crop-yield statistics obviously accept lower statistical quality than was the case earlier, mainly for cost reasons. When looking at costs, the quality aspects and other advantages/disadvantages of the different methods must be considered. A proper balance should be decided on the basis of cost/benefit studies for the crop-yield statistics.

Acknowledgments

For providing invaluable material for this report, the author is most grateful to Mr. Per Olof Olofsson, former Head of the Unit for Agricultural Statistics at Statistics Sweden, and Mr. Bertil Århammar at the staff for Crop Production Statistics at Statistics Sweden. They have also given their comments on this paper.

References

Århammar, B. (1996), *Skördeuppskattning genom intervjuer 1995*, Statistics Sweden, PM M/LP 1996:1.

Århammar, B. (1997), *Skördeuppskattning genom intervjuer 1996*, Statistics Sweden, PM M/LP 1997:2.

Århammar, B. (1998), *Skördeuppskattning genom intervjuer 1997*, Statistics Sweden, PM M/LP 1998:1.

Olofsson, P.O. (1993), "Crop-Yield Statistics based on Mail Enquiries to Farmers - Recent Swedish Experiences," Eurostat, Working Party "Crop Products Statistics" of The Agricultural Statistics Committee, Working Document, Doc. AGRI/PE/395, Luxembourg.

Olofsson, P.O. (1994), "Crop-Yield Forecasting Methods," Proceedings of the seminar Villefranche-sur-Mer, 24-27 October 1994, France.

Olofsson, P.O. (1997), *Objective Crop-Yield Measurements in Sweden*, Statistics Sweden, Statistical Report, M/LP 1997:4.

Olofsson, P.O. and Hagblad, L. (1992), *Methods for Cereal Production in Sweden*, Statistics Sweden, PM A/LA 1992:19.

Statistiska centralbyrån (1997), *Skördeuppskattningar 1997, Omfattning och metoder*, Statistiska Meddelanden, J 12 SM 9702. (Summary in english)

Statistics Sweden (1992), *The Objective Crop-Yield Surveys in Sweden*, a description.

Statistics Sweden (1994), *Ett Nytt Skördestatistiskt System*, Slutrapport, December 1994.

Statistics Sweden (1995), *Methodological report according to the Council Regulation No. 837/90 on cereal production and No. 959/93 on crop products other than cereals.*

Statistics Sweden (1997), *Skördeuppskattning, Handbok (Manual) 1997*.