Utilizing the African postharvest loss information system (APHLIS) in feed the future countries

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Abstract

APHLIS is a web-based framework that aids post-harvest experts in documenting, analyzing, and estimating post-harvest grain weight losses in sub-Saharan Africa. APHLIS is unique in that it can be used to estimate post-harvest losses (PHLs) at specific steps in the postharvest value chain instead of only storage losses, which have traditionally received the most attention. Key limitations of APHLIS are that loss estimates are calculated using a relatively small pool of loss data and that only grain quantity, and not grain quality losses are predicted by the system. Feed the Future (FtF) Innovation Lab project teams have partnered with local post-harvest experts in Africa, Asia, and Central America. The initial objectives of these teams are post-harvest value chain loss assessments that include both grain quantity and quality losses. This project evaluated how APHLIS could be utilized, and contributed to, by FtF country teams, and how it can be adapted to incorporate grain quality loss information. The teams can use the PHL calculator provided by APHLIS to generate cumulative loss figures for their projects. Teams can also contribute new loss and production data to the database. The accuracy and relevance of APHLIS PHL information is improved by adding updated figures to the database. APHLIS can be scaled for use globally by incorporating loss data gathered by project teams in other countries. Grain quality loss information such as mycotoxin contamination can be tracked and possibly linked to weight losses to better understand the total amount of postharvest grain losses.

Keywords: post-harvest losses, food security, African postharvest loss information system, mycotoxin contamination, grain quality

1. Introduction

Accurate grain post-harvest loss (PHL) assessments are critical in prioritizing, planning, and evaluating PHL reduction project goals. Post-harvest loss estimates can be utilized as a tool for assessing such projects, targeting improvements in a country's cereal grain supply chain, can help inform the creation of food balance sheets that help predict future food shortages, and inform policy decisions about grain imports and exports.

The African Postharvest Loss Information System (APHLIS) is an internet-based framework that aids post-harvest experts in documenting, analyzing, and estimating post-harvest losses (PHL) of cereal grains in sub-Saharan Africa (SSA). APHLIS is unique in that it can be used to estimate PHLs at specific points in the post-harvest value chain rather than only storage losses, which have traditionally received the most attention in loss studies.

A thorough explanation and review of APHLIS was done by Hodges et al. (2010). Considerations how APHLIS may be used in PHL reduction projects were done by Hodges and Stathers (2013), and Hodges et al. (2013).

APHLIS deals only with weight loss of cereal grains in SSA. As useful as this is, actors in the post-harvest value chain could also benefit by having estimates about grain quality factors (such as mycotoxin contamination) and by having loss estimates available on a global scale.

Nineteen developing countries have been partnered with as part of Feed the Future (FtF), the U.S. government's food security initiative. The goals of FtF are to strengthen the cereal grain value chains, reduce post-harvest losses, and increase food security in these countries. Here we consider how APHLIS can be utilized as a tool to aid intervention projects in these countries, how it may be adapted for use globally, and how APHLIS might be improved by incorporating grain quality data. This review was written with Feed the Future countries in mind, but can apply to any country with post-harvest loss work being done.

2. APHLIS background

Loss estimates generated by APHLIS are based on historical PHL data found in the literature and include both measured loss studies and informed guesstimates from farmers, extension workers, and other experts on the ground (Hodges and Stathers, 2013). At the time of this writing, data from nearly 80 papers published from 1972 to 2011 are utilized for APHLIS loss estimates. Table 1 shows the total number of loss figures at various points in the value chain that are utilized by APHLIS. The number of loss figures for maize far outweighs those of other grains, and the number of figures for storage losses far outweighs those at other points in the post-harvest value chain.

Table 1 Number of post-harvest loss estimates used by APHLIS at various points in the post-harvest value chain. (includes post-harvest questionnaires and measured loss studies)

	Cereal grains	**Maize**	**Millet**	**Sorghum**	**Rice**	**Wheat**	**Barley**	**Teff**	**Total**
Field drying	3	7	1	1	1	0	0	0	13
Platform drying	0	3	0	0	0	0	0	0	3
Threshing/shelling	3	3	0	0	1	0	0	0	7
Winnowing	1	0	0	0	1	0	0	0	2
Transport to store	3	1	0	0	1	0	0	0	5
Storage	-	43	2	16	3	6	2	1	73
Transport to market	-	1	0	0	0	0	0	0	1
Total	10	58	3	17	7	6	2	1	104

Source: Adapted from Rembold et al. (2011)

Because loss data is not comprehensive for every crop and value chain point, they have been grouped according to similar crop type, climate type, and farm size. This allows regions, crops, and value chain points that lack their own loss figures to use loss data from similar climates and farming systems. Because the loss data is shared, it is important to realize that a PHL estimate for a province may not actually use any loss data from that province, or even from the same country, the assumption being that similar climate types and cropping systems will experience similar losses.

To estimate cereal losses in a given situation, APHLIS selects the most relevant loss data from the database and creates a PHL profile for the situation at hand. The PHL profile is an

average of the relevant loss figures (as percent weight loss) for each point in the value chain. "Seasonal factors" that have an impact on PHL are taken into account. These include the percent of grain marketed within three months, whether or not there is rain during harvest, storage duration, and presence of *Prostephanus truncatus* (for maize only). APHLIS then calculates the expected cumulative loss by applying the PHL profile and seasonal factors to cereal production data. APHLIS depends on a network of national experts from universities, research institutions, and government agencies in SSA to provide data on seasonal factors.

3. Components of APHLIS

The APHLIS website (http://www.aphlis.net) is the "face" of APHLIS to the post-harvest community. It provides GIS based maps which graphically present losses, climate, and PHL factor information. The maps facilitate PHL comparisons between crops, across countries and provinces, and between different years. The maps also display information about country climate classification and presence of LGB. The website also has cereal grain loss tables for various countries and provinces in SSA. The losses tables are linked to information about the data sources from which the loss estimates are derived, and the quality of the sources (i.e., how relevant the data source is to a specific province or farm). In each case, the quantity and quality of data will have a large impact on the accuracy of the PHL estimate.

The website provides online resources that would be helpful to PHL reduction projects including country narratives that explain the climate, crop production, loss situations, and describe ongoing PHL reduction programs in specific countries. Other resources include links to PHL reduction tips and advice, PHL assessment guides, weight and quality loss prevention manuals, and contact information for network members.

A PHL calculator can be downloaded as an Excel spreadsheet and modified to reflect more current data or data from other geographic areas to suit specific needs, as the calculator allows the user to input their specific loss information in a given farming situation.

4. Relevance to Feed the Future Countries

4.1. How can the APHLIS framework and database be used in Feed the Future countries?

Post-harvest loss reduction projects can utilize APHLIS in several ways. The APHLIS calculator can be downloaded and modified to generate loss estimates for any geographic region, province or country. Projects can use the PHL calculator to calculate cumulative cereal grain weight loss by entering their own measured loss values instead of the default ones. The estimates generated would then be representative of the project's geographical scale and can be used as a tool to monitor and evaluate project performance.

Some grains that the Feed the Future country teams are interested in (sesame and chickpeas, for example) are not tracked by APHLIS at this time. There are no studies for wheat, barley, or teff at any point in the post-harvest chain except storage, and only one each for millet and sorghum involving field drying. For this reason, loss estimates for grains other than maize (and possibly sorghum) would probably not be particularly reliable until PHL data for these grains and value chain points are obtained.

4.2. How can the Feed the Future country project teams contribute to APHLIS?

Feed the Future project teams can contribute to APHLIS in several ways. The first is by providing new PHL data for the APHLIS database itself. The hope is to replace old data with more current and reliable loss figures as new PHL data becomes available (Hodges et al., 2010). Loss estimates are expected to become more accurate as measured PHL data and loss

factors are collected at each step of the post-harvest value chain and incorporated to APHLIS. Field teams and project leaders can send new loss data to APHLIS3@gmail.com, along with details about how the losses were measured.

As discussed above, one limitation of APHLIS is the lack of measured loss studies at points in the post-harvest value chain other than storage, and for cereal grains other than maize. The database uses literature mostly focused in Africa, but also includes PHL studies performed in India (three studies), Nepal, Bangladesh, and Asia (one study each). Loss data from these countries are already being utilized to estimate PHLs in sub-Saharan Africa. Loss data from PHL studies done in Feed the Future countries would be welcome in the APHLIS database, provided the data is of equal or better quality than that currently used.

The factors that APHLIS uses to predict PHLs (i.e. climate type, farm size, and crop type) are similar among the countries in SSA as well as Feed the Future countries. With regards to climate, APHLIS uses Koppen climate codes, as these are widely known. The climate groupings used in APHLIS are “Tropical Savannah”, “Hot Semi-Arid”, “Humid Subtropical”, “Subtropical Highland”, and “Hot Desert” (Koppen climate codes Aw, BSh, Cwa, Cwb, and BWh, respectively). Table 2 shows the climate codes associated with Feed the Future countries. With the exception of Tajikistan, each country has at least one of these climate types within its borders. Feed the Future countries and countries in SSA have many of the same major factors that APHLIS uses to generate PHL estimates in common (e.g. farm size, crop type, climate type). This should facilitate incorporating new PHL data into APHLIS. Table 2 also displays the number of PHL studies from Feed the Future countries incorporated into the APHLIS database.

Table 2 Köppen climate classification code(s) and number of PHL studies utilized by APHLIS in Feed the Future target countries.

Country	Climate code(s)	Number of PHL studies
Bangladesh	**Aw** Am **Cwa**	1
Cambodia	**Aw** Am	0
Ethiopia	**AwBShCwb**Cfb	9
Ghana	**Aw** Am	4
Guatemala	**Aw** Am **BSh**	0
Haiti	**Aw**	0
Honduras	**Aw** Am	0
Kenya	**Aw** As **BSh**Cfb	4
Liberia	**Aw** Am	0
Malawi	**AwCwa**	5
Mali	**AwBShBWh**	3
Mozambique	**AwBShCwa**	0
Nepal	**CwaCwb**Dwb ET	1
Rwanda	**AwCwa**Cfa	0
Senegal	**Aw**BWh**BSh**	0
Tajikistan	ET CsaDsaDsbCsa	0
Tanzania	**Aw** Am **BShCwaCwb**	4
Uganda	**Aw** AmAf	0
Zambia	**AwBShCwa**	3

Bold codes indicate those used in APHLIS estimates.
A: equatorial, B: arid, C: warm temperate, D: snow, E: polar W: desert, S: steppe, f: fully humid, s: dry summer, w: dry winter, m: monsoonal, h: hot arid, a: hot summer, b: warm summer, T: polar tundra
Source: Kottek et al., 2006

In addition to data on loss data, data on the seasonal factors contributing to the losses (*P. truncatus* infestation, rain during harvest, storage and handling methods, storage duration, and percentage of grain immediately marketed) are also needed.

Another contribution would be the evaluation of current (or the development of new) rapid loss determination methods. Fieldwork of this sort can be costly and time consuming, so standardized methods that combine rapidity and accuracy are needed. Loss assessment manuals have been produced by various agencies that may be of some help to FtF country project teams. Consistent and reliable data are needed to make the APHLIS loss estimates more accurate, so the methods by which loss data are collected should be sound.

4.3. How can grain quality loss data be documented and utilized by APHLIS?

Grain quantity (i.e., weight) losses are relatively easy to measure, but the negative economic impact of poor grain quality characteristics (such as moisture content, insect damage, mold damage, mycotoxin content, composition, end use quality) are generally more challenging to measure and quantify. It is only by combining quantity and quality losses that the total impact of post-harvest loss can be understood and valued.

Little work has been done to combine quantity and quality losses into a comprehensive PHL figure. APHLIS coordinators have considered how to incorporate both weight loss and grain quality data into the final PHL estimate. It has been assumed that the only term which quantity and quality losses have in common are economic, but while grain weight losses are relatively easy to quantify (lost grain is simply gone), quantifying grain quality is more complicated. Owners of low quality grain may be forced into lower value markets (such as animal feed) but still be able to sell the entire lot of grain albeit at a lower price. In some instances, low quality grain may receive a higher price during times of scarcity than high quality grain during times of plenty. Except in the case of grain that is spoiled beyond what humans and animals will consume (and is therefore counted a total loss), these quality issues are not easily linked to weight loss to provide a clear understanding of total PHL. Such losses are often greater than weight losses in terms of financial impact (Hodges and Maritime, 2012), and can also become a human and animal food safety concern when consumed (e.g., health problems caused by molds or mycotoxins).

As of now, APHLIS only incorporates grain quality loss in the case of LGB infestation. Studies were performed which showed storage losses were twice as high in LGB infested maize compared to non-infested maize (Boxall, 2002; Dick, 1988; Hodges et al., 1983). Therefore, APHLIS accounts for LGB infestation in the PHL profile calculation by giving maize with LGB a 2x multiplier for storage losses.

Ideally, APHLIS should be able to estimate the quantity loss of grain tainted by mycotoxins as part of its total PHL estimates. One way to do this would be to base loss amounts on standard mycotoxin rejection levels found in the Codex Alimentarius or rejection levels in specific countries based on official grain standards or government regulations. Levels above the rejection amount would be considered a total loss. However, the only Codex cereal grain mycotoxin standard is for Ochratoxin A in raw wheat, barley, and rye (5 parts per billion). The majority of countries in Africa either do not have, or do not enforce, specific mycotoxin regulations (FAO, 2004), and regulations in countries that do have them vary considerably. This approach would be limited in areas that, for whatever reason, do not test for mycotoxins or that fall outside the regulated grain trade. However, mycotoxin rapid test kits are becoming less expensive and more accurate all the time. Introduction of rapid testing along with grain quality education and training initiatives could help facilitate mycotoxin quantification in more FtF countries.

As a first step toward tracking mycotoxins, APHLIS could simply document the presence, type, and amount of mycotoxins in harvested grain without converting the quality loss into weight loss. A user could track mycotoxin levels in countries over time, providing a convenient way to track and evaluate post-harvest loss reduction intervention impact. Mycotoxin contamination studies in the literature appear to exist that might be incorporated into the APHLIS database in a fashion similar to the weight loss data.

5. Conclusions

APHLIS is a virtual coordinating space capable of linking the international post-harvest community to document and estimate PHLs of durable crops, plan and evaluate PHL prevention and reduction programs, and help form agricultural policy decisions.

- APHLIS can be used to assist PHL reduction efforts in Feed the Future countries. However, given that APHLIS uses mostly SSA PHL figures in its calculations, the loss estimates would need to be validated. For example, are PHL for a tropical maize farm in SSA similar to PHL for a tropical maize farm in Guatemala or Bangladesh?
- Thus, APHLIS uses a relatively small pool of data to estimate losses along value chains over a wide range of climates, farm types, farming practices, cropping systems, and crop types. Consequently, the estimates calculated by APHLIS are quite generalized and will likely be relatively inaccurate until more reliable PHL data is incorporated into the database.
- Quality loss factors other than LGB infestation are not included in APHLIS loss estimates. There are plans to further develop APHLIS by including a qualitative loss section that will cover mycotoxins. APHLIS is technically capable of keeping track of the location, amount, and type of mycotoxins in grains. More information is needed on mycotoxin sampling protocols and analysis tools in project regions.
- Converting grain quality data into quantity loss to predict overall PHL is complicated. More research should be done to link insect infestation, mycotoxin contamination, and other grain quality factors to the amount of total PHL at a given step in the post-harvest value chain. Until a method to determine a total PHL figure is developed, quality data could be incorporated as a separate feature of the APHLIS system.
- Existing quantitative data about mycotoxin contamination in the literature could be incorporated into the APHLIS database. In the future, mycotoxin contamination estimates could be arrived at in a similar manner to weight loss estimates.
- APHLIS gives equal weight to all data used to create the PHL profile for a province or farm. The loss estimates may be improved by giving more weight to data that is more relevant and recent to a particular situation.
- Certain grains that are of interest to Feed the Future countries (sesame and chickpeas, for instance) are not currently tracked. FtF country project teams could contribute this information to APHLIS, and thus expand its relevance and global scope.

PHL reduction project teams in Feed the Future countries and elsewhere are encouraged to submit seasonal factor and PHL data to APHLIS coordinators.

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References

Boxall, R.A., 2002. Damage and loss caused by the Larger Grain Borer *Prostephanus truncatus.* Integrated Pest Management Reviews 7, 105-121.

Dick, K., 1988. A review of insect infestation of maize in farm storage in Africa with special reference to the ecology and control of *Prostephanus truncatus.* Overseas Development Natural Resources Institute, Chatham, UK: Bulletin 18 pp. 42.

FAO, (Food and Agriculture Organization) of the United Nations, 2004. Worldwide regulations for mycotoxins in food and feed in 2003. FAO Food and Nutrition Paper 81.

Hodges R.J., Dunstan, W.R., Magazini, I., Golob, P., 1983. An outbreak of *Prostephanus truncatus* (Horn) (Coleoptera: Bostrichidae) in East Africa. Protection Ecology 5, 183-194.

Hodges, R.J., Bernard, M., Knipschild, H., Rembold, F., 2010. African Postharvest Losses Information System – a network for the estimation of cereal weight losses, in: Carvalho, M.O., Fields, P.G., Adler, C.S., Arthur, F.H., Athanassiou, C.G., Campbell, J.F., Fleurat-Lessard, F., Flinn, P.W., Hodges, R.J., Isikber, A.A., Navarro, S., Noyes, R.T., Riudavets, J., Sinha, K.K., Thorpe, G.R., Timlick, B.H., Trematerra, P., White, N.D.G. (Eds.), Proceedings of the 10th International Working Conference on Stored-product Protection. Julius Kuhn-Institut, Estoril, Portugal, pp. 956-962.

Hodges, R.J., Maritime, C., 2012. Postharvest Quality Losses of Cereal Grains in Sub-Saharan Africa. http://www.aphlis.net/downloads/Postharvest_quality_losses%20review_Sept_2012_revised.pdf. Accessed August 6, 2014.

Hodges, R.J., Stathers, T.E., 2013. Facing the food crisis: How African smallholders can reduce postharvest cereal losses by supplying better quality grain. Outlooks on Pest Management 24, 217-221.

Hodges, R.J., Bennett, B., Bernard, M., Rembold, F., 2013. Tackling post-harvest cereal losses in sub-Saharan Africa. Rural 21: The International Journal for Rural Development 47, 16-18.

Lipton, M., 1982. Post-harvest technology and the reduction of hunger. IDS Bulletin 13(3) 4-11.

Kottek, M., Grieser, J., Beck, C., Rudolf, B., Rubel, F., 2006. World Map of the Köppen-Geiger climate classification updated. Meteorologische Zeitschrift 15, 259-263.

Rembold, F., Hodges, R., Bernard, M., Knipschild, H., Léo, O., 2011. The African Postharvest Losses Information System (APHLIS): an innovative framework to analyse and compute quantitative postharvest losses for cereals under different farming and environmental conditions in East and Southern Africa. Project Report. Publications Office of the European Union / European Commission - Joint Research Centre - Institute of Environment and Sustainability (JRC-IES), Luxembourg. (doi:10.2788/40345)