

Statistical Methodology

Name of Survey: Agricultural Resource Management Survey (ARMS 2) Phase II: Corn Production Practices Cost Report, Cotton Production Practices Report, and Rice Production Practices Cost Report.

Name of Summary: Agricultural Chemical Usage, 2021 Corn, Cotton, and Rice Summary
(Access at USDA-NASS Quick Stats <http://quickstats.nass.usda.gov/>. See Program: Survey, Sector: Environmental, Group: Field Crops, Commodity: Corn, Cotton, or Rice)

Data Collection Period: September to December 2021

Target Population and Sampling Frame: The target population for the ARMS Phase II is the official USDA farm population, within the pre-defined program states, which is defined as “all establishments that sold or would normally have sold at least \$1,000 of agricultural products during the year,” excluding abnormal or institutional farms.

Program states are selected to both minimize the total number of states selected and ensure at least 80 percent coverage of target commodity planted acreage.

The USDA-NASS list sampling frame, including all known U.S. operations qualifying as a farm under the USDA-NASS definition, accounting for approximately 90 percent of total U.S. land in farms, is the frame used to derive the sample. Control data is used to exclude abnormal or institutional farms.

Sampling Methods: The ARMS 2 is selected as a follow-on survey to the ARMS Phase I (ARMS 1) Screening Survey. The ARMS 1 sample is selected from the NASS list frame using Sequential Interval Poisson Sampling to minimize overlap between the current year’s ARMS 1 sample, last year’s ARMS 1 sample, and other NASS surveys. Each eligible operation on the list frame is given a positive probability of selection. A given operation’s probability of selection is calculated based on farm value of sales (FVS) strata membership and acreage levels of the ARMS 2 commodities. After the screening phase, operations which report positive acreage for ARMS 2 target commodities are subsampled for the ARMS 2 survey. Multiple operating arrangements are further subsampled so that only one suboperation is included in the ARMS 2 sample. The sampling weights are adjusted upwards to account for this subsampling.

One or both ARMS 2 components may be conducted each year; the Production Practices Report Survey (PPR) and the Production Practices and Costs Report Survey (PPCR). The PPR is conducted in support of NASS’s chemical usage program exclusively. The PPCR is conducted in cooperation with USDA’s Economic Research Service as part of the three phase ARMS cost of production program.

Sample Unit and Reporting Unit: The sample unit is the individual operation. The reporting unit is a single, randomly selected field from all the operation’s fields planted to the ARMS 2 field crop.

Modes of Data Collection: Mobile computer assisted personal interview web instrument.

Selected Terms and Definitions

Active Ingredient: The specific pesticide ingredient which kills or controls the target pest(s) or other target material(s), or otherwise results in the pesticide effect(s). All pesticide-use estimates in report are published per active ingredient (rather than per product); one or more active ingredients are present in known amounts in the pesticide products reported in survey.

Rate and Total Applied estimates were reported in a single unit of equivalence, per active ingredient. For salt, ester, or amine active ingredients, estimates were published in the parent acid equivalents. For example, the acid derivatives glyphosate isopropylamine salt and 2,4-D, 2-EHE were published in the glyphosate and 2,4-D equivalents, respectively. For copper compounds, estimates were published in the metallic copper equivalent.

Active Ingredient Code: A unique code assigned to each active ingredient upon registration with the Environmental Protection Agency's Office of Pesticide Programs, to facilitate pesticide regulation.

Area Applied, Percent: Percent of total planted acres which received one or more applications of a specific fertilizer nutrient or pesticide active ingredient. (*In Quick Stats: Treated, Measured as Percent of Area Planted*)

Avoidance: A strategy in which the detrimental effects of pests on crops are mitigated or eliminated solely through various cultural practices. Avoidance is one of four classes of pest-management practices for which data are included in the report.

Beneficial Insects: Insects (small invertebrate animals, mostly of arthropod classes Insecta and Arachnida), which are collected and introduced onto crop acres because of their value in biological control as predators on harmful insects and parasites.

Chemigation: Application of agricultural chemicals, including pesticide products, by injection into irrigation water.

Crop Year: The period starting immediately after harvest of the previous year's crop and ending at harvest of the current year's crop.

Farm: Any place from which \$1,000 or more of agricultural products were produced and sold, or normally would have been sold, during the year. Government payments are included in sales.

Fertilizer: A soil-enriching agricultural input which contains one or more plant nutrients. Data for three primary macronutrients nitrogen (N), phosphate (P₂O₅), and potash (K₂O), and the secondary macronutrient sulfur (S) are included in report.

Fungi: Various organisms of the kingdom Fungi, which obtain nutrients by decomposing plant or other organic life. This pest group includes mushrooms, molds, mildews, smuts, rusts, and yeasts. Fungal infestations have the potential to reduce crop production and/or lower the grade quality of the host crop.

Mechanism of Action (MOA): The method or biological pathway by which the pesticide or active ingredient kills or controls the target pest(s) or other target material(s).

Minimum or Reduced Tillage: Tillage practices prior to planting which result in a minimum of 30 percent or more of crop residue being retained on the surface following planting.

Monitoring: A strategy involving the observance or detection of pests through systematic sampling, counting, or other forms of scouting. Monitoring may include prediction of pest population levels through the observance of environmental factors such as weather or soil and crop quality. Monitoring is one of four classes of pest-management practices for which data are included in the report.

Nematodes: Unsegmented, parasitic worms of the phylum Nematoda. Prominent animal pest of wheat and other field crops with the potential to be highly destructive, lowering crop production and grade quality significantly.

Number of Applications: The average number of times a treated acre received a specific fertilizer nutrient or pesticide active ingredient. (*In Quick Stats: Applications, Measured in Number*)

Pesticide: Defined by the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) as “(1) any substance or mixture of substances intended for preventing, destroying, repelling or mitigating any pest, (2) any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant, and (3) any nitrogen stabilizer...”(*Title 7, U.S. Code, 136*). Under FIFRA, pesticides are registered and regulated through the Environmental Protection Agency’s Office of Pesticide Programs. Four classes of pesticides are included in report: (1) herbicides targeting weeds, (2) insecticides targeting insects (3) fungicides targeting fungi, and (4) other chemicals targeting all other pests or other materials (including extraneous crop foliage).

Pheromone: A chemical substance produced by an insect which serves as a stimulus to other individuals of the same species for one or more behavioral responses.

Prevention: A strategy in which a pest population is kept from infesting a crop or field, by taking various preceding actions. Prevention is one of four classes of pest-management practices for which data are included in the report.

Rate per Application: Ratio indicating pounds (lbs) of a fertilizer primary nutrient or pesticide active ingredient (or associated acid or metallic equivalent) applied, per single application, per planted acre. (*In Quick Stats: Applications, Measured in Lb/Acre/Application*)

Rate per Crop Year: Ratio indicating pounds (lbs) of a fertilizer primary nutrient or pesticide active ingredient (or associated acid or metallic equivalent) applied, counting all applications per crop year, per planted acre. (*In Quick Stats: Applications, Measured in Lb/Acre/Year*)

Suppression: A strategy which involves the control or reduction of existing pest populations in order to mitigate crop damage. May include physical or biological controls, or management of resistance build-up through pesticide rotation. Suppression is one of four classes of pest-management practices for which data are included in the report.

Data Review and Estimation Procedures: Headquarter (HQ) statisticians execute a summary that generates program state level indications. Regional Field Offices are responsible for performing a detailed review of their survey results and providing comments that justify their survey results. HQ statisticians conduct a final review of survey results from all program states. Any irregularities revealed by the summary must be investigated and, if necessary, resolved. After final review, state and program state level summary results are adopted as official estimates.

There are three main types of data that NASS estimates for these surveys - fertilizer application, pesticide application, and pest management data. For the application data, NASS collects information about the commercial fertilizers and pesticides applied during the crop year. For fertilizer, these applications are collected as either actual pounds or percent analysis of Nitrogen (N), Phosphate (P₂O₅), Potash (K₂O), and Sulfur (S). Fertilizer data are then published in actual pounds of nutrient used. For pesticides, these applications are collected at the product level, generally per application. These product level data are converted to pounds of active ingredient (or the acid or metallic equivalent, where applicable), summarized, and published. If there are not a sufficient number of reports, the data are suppressed from

publication, along with any needed complementary suppression. Estimates were published if five or more reports were received and summarized for a given variable and if the indication was greater than or equal to one half of the pre-determined rounding unit for that variable. NASS maintains chemical use databases which contain pesticide product recommended use ranges and active ingredient concentrations per product. These databases are used to review and summarize product usage data.

Estimates are calculated and published at the population-level using official USDA-NASS 2021 acreage estimates by state (published in “Crop Production – 2021 Summary” [ISSN: 1057-7823] <https://downloads.usda.library.cornell.edu/usda-esmis/files/k3569432s/sn00c1252/g158cj98r/cropan22.pdf>)

For this reason, all published estimates apply at the population-level defined by these official estimates. Note that although official USDA-NASS crop acreage estimates are subject to revision, the chemical use estimates are not subject to revision.

For both fertilizer and pesticide application data, NASS estimates area applied (percent of planted acres treated), number of applications, rate per application (pounds of active ingredient or acid equivalent per acre), rate per crop year (number of applications multiplied by rate per application), and total amount applied.

Distribution and reliability measures were published if 30 or more reports were received and summarized for a given variable. Distribution and reliability measures are given by active ingredient for the percent of acres treated, number of applications, rate per application, and rate per crop year. Rate distribution tables include the median, the 10th and 90th percentiles, the mean, and the coefficient of variation (CV) for an active ingredient when a sufficient number of farm operators report applying it on the specified crop.

The pest management data are collected through a series of yes/no questions pertaining to specific pest management practices. Pest management data are collected for the randomly chosen field. From these data, NASS releases the percent of operations using the practice as well as the percent of acreage. The percent of acreage assumes that the operation treats all fields of a particular commodity in the same way.

Reliability: Estimates were subject to sampling variability; sampling variability was measured by the coefficient of variation (CV), expressed as a percent of the estimate. Coefficients of variation were derived and published for the percent of acres treated, number of applications, rate per application, and rate per crop year. In general, a lower CV indicates a more precise estimate. Coefficients of variation differed considerably by variable, chemical, and crop. The narrower the numerical range of responses per variable and the larger the number of positive responses per variable, the smaller the sampling variability. For these reasons, CVs were generally lower for active ingredient rate of application estimates and for estimates associated with the most often reported active ingredients. Application rates reported almost always fell within the manufacturer’s relatively narrow recommended usage range, and a relatively large number of reports were received for the most widely used active ingredients.

Estimates were additionally subject to non-sampling errors. These errors include reporting, recording, editing, and imputation errors. Steps are taken to minimize the impact of these errors, such as comprehensive interviewer training, validation and verification of processing systems, detailed computer edits, and the analysis tool. Re-contact with respondents is conducted on an as needed basis.

Revision Policy: Estimates are final at first publication and are not subject to revision.