Agricultural Chemical Usage – Fruit Methodology and Quality Measures

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Fruit Chemical Usage Survey: Methodology and Chemical Usage Statistics

Scope and Purpose: The National Agricultural Statistics Service (NASS) Fruit Chemical Use Survey (FCUS) collects entire farm level chemical use data from growers of select fruits in program states. The fruit and vegetable chemical surveys have been conducted in alternating years since 1990 with data collected on fruits in odd numbered years and vegetables in even numbered years. The states involved and the commodities surveyed are selected based on NASS acres planted and evaluated each cycle to ensure maximum coverage.

The states involved (referred to as "program states") and the commodities surveyed are selected based on NASS acres planted and evaluated each cycle to ensure maximum coverage. NASS aims to cover at a minimum 80 percent of targeted fruit crop acres in the United States. Farm level data are combined during summary and, pending compliance with disclosure rules, published at state and national levels. Data are published for 21 targeted fruit crops in 12 states.

Survey Timeline: Data collection begins on September 1 and lasts until mid-January of the following year to ensure completion of the crop year. NASS Regional Field Offices (RFOs) along with NASS Headquarters (HQ) spend the next several months reviewing reported data for reasonableness and conduct producer follow-ups, as necessary. The estimates are released to the NASS Quick Stats 2.0 system during the fourth week in July.

Sampling: The target population for the FCUS is all agricultural establishments with more than $1,000 in agricultural sales (or potential sales). NASS uses a dual frame approach, consisting of list frame and area frame components, to provide complete coverage of this target population.

NASS maintains a list of farm and ranch operators. NASS is constantly seeking new operations from outside list sources confirmed to be qualifying farms before being added to the list. A profile, known as control data, of each operation is maintained which indicates what the farm has historically produced and a general indication of size. This information allows NASS to define sampling populations that are specific to each survey and employ advanced and more efficient sample designs.

The FCUS list sample is selected based on a calculated Farm Value of Sales (FVS). All farms on the list frame with an estimated FVS of $1,000 or more are eligible. The value of sales control data need not be exact as it is used to stratify similar list operations into homogeneous groups.

Sampling Frames and Methods: The sample for the FCUS is selected from the NASS List Sampling Frame. The population of interest is fruit growers having positive list frame acreage for one or more of the target fruit crops. The sample will use the Multivariate Probability Proportional to Size (MPPS) design, in which each reporting unit's probability of selection depends on its total acres of the target crops. The reporting unit is one farm associated with the selected operator. Sampled units that were known to have multiple farms had one farm randomly selected as the reporting unit.

The 2019 FCUS consists of a single data collection phase. The sample size for the FCUS is 5,951.

Data Collection and Editing: All federal data collections require approval by the Office of Management and Budget (OMB). NASS must document the public need for the data, show the design applies sound statistical practice, ensure the data do not already exist elsewhere, and show that the public is not excessively burdened. The fruit chemical use questionnaires must display an active OMB number that gives NASS the authority to conduct the survey, a statement of the survey purpose and the use of the collected data, a response burden statement that estimates the time required to complete the form, a confidentiality statement that the respondent's information will be protected from disclosure, and a statement that response to the survey is voluntary and not required by law.

Using these questionnaires, chemical use and pest management data are collected only by personal visit from an enumerator. Postcards are mailed to producers prior to field contact stating the importance of cooperation and that contact will be made in the coming weeks. Once contact is made by the field enumerator, an appointment will be set up to collect data when the farm operator indicates no further chemical applications are remaining. The field enumerator returns the questionnaires to the NASS RFO for editing and data entry. Questionnaire responses are captured and edited for consistency using automated systems, and a report of questionnaires with errors is generated. NASS statisticians will correct the errors on the report or comment to their validity if the data are deemed to be correct.

Analysis Tools: Chemical use data are processed through an interactive data analysis tool which displays data for all reports by product or commodity. This application tool provides various scatter plots, graphs, tables, charts, and listing tools that allow the analyst to compare an individual record to other similar records within a program state. Outliers and unusual data relationships are investigated by RFO and HQ statisticians to determine validity. Suspect data found to be in error are corrected, while data found to be correct are kept.

Nonsampling Errors: Nonsampling errors are present in any survey process. 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.

Nonresponse Adjustment: Response to the FCUS is voluntary. Some producers refuse to participate in the survey, others cannot be located during the data collection period, and some submit incomplete reports. These nonrespondents must be accounted for if accurate estimates of total chemical usage are to be made. For this survey, item level nonresponse is accounted for by imputing data where there are missing values. Imputed rates of application for chemicals are calculated through an automated imputation system that calculates an unweighted mean for an imputation group based on commodity, state, and product. When a group lacks sufficient responses, groups are collapsed to preserve as much of the homogeneity as possible.

Calibration: Calibration is a weighting technique used in survey sampling to adjust the survey weights for sampled elements so that the weighted sum of a set of benchmark variables equals a pre-determined set of values for the population. The input to the calibration algorithm is the weights generated from the sampling procedures. Sampling weights are calculated based on numerous factors so that the sample allocations are representative of the entire population of farms at the state level for the target fruit crop(s) in that state. Due to survey nonresponse, weights are adjusted through a calibration algorithm. Calibration adjusts the sampling weights so the expanded data will match planted acreage totals from the June Noncitrus Fruits and Nuts report and the August Citrus Fruits Summary. This ensures that the chemical data collected will accurately represent the chemical usage for all target fruit crops for the entire target population.

Estimators: The FCUS utilizes direct expansions and/or ratio expansions for all survey indications. Direct expansions are calculated by summing the reported or imputed chemical data values by the calibrated weights. Similarly, ratios are calculated by applying calibrated weights and nonresponse adjustments to data when both the numerator and denominator are reported. Variance estimates are computed for all expansions.

Outliers: NASS conducts a review of outliers found in the chemical use data by reviewing application rates for all records for the same product and commodity combinations. The RFO and HQ statisticians work together to ensure the data are as accurate as possible. The RFO statisticians review outliers within their program states, and the HQ statistician examines outliers across all program states for the published categories. A determination is made as to whether an adjustment to the application data is required. Most outliers trace back to unique situations that do not exist in the target population as much as the survey weight would indicate.

Estimation: HQ statisticians execute a summary that generates state level and national level indications. RFO statisticians 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 states. Any irregularities revealed by the summary must be investigated and, if necessary, resolved. After final review, national level summary results are adopted as official national estimates except in cases where strong justification supports deviating from survey totals.

For this survey there are two main types of data that NASS estimates - pesticide application and pest management data. For the application data, NASS collects information about pesticides applied during the crop year. For pesticides, these applications are

collected at the product level, generally per application. These product level data are converted to pounds of active ingredient, summarized, and published. If there are not a sufficient number of reports, the data are suppressed from publication, along with any needed complementary suppression.

For the pesticide application data, NASS estimates area applied (percent 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. In order to publish data for an active ingredient, there must be a minimum number of reports for the specific active ingredient at the summary level (by crop, by state, or all program states). If there are not a sufficient number of reports, the data is suppressed from publication, along with any needed complementary suppression

The standard deviation for each active ingredient is calculated to determine data distribution for each crop. Chemical distribution rates are given by active ingredient for the Percent of Acres Treated, Number of Applications, Rate per Application, and Rate per Crop Year. The distribution tables include the coefficient of variation (CV) for an active ingredient when at least 30 farm operators report applying it on the specified crop.

The pest management data are generally a series of yes/no questions pertaining to specific pest management practices. Pest management data are collected for the entire operation. 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, if the operation uses the practice on one acre, it is used on all acres. This also means that the pest management data are not crop specific; they are distributed across all fruit acres.

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 the 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 the 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 Percent of 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 Percent of*)

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 (P_2O_5), and potash (K_20), and the secondary macronutrient sulfur (S) are included in the 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 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, Measure 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 the 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, counting all applications per crop year, per Percent of 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.

Quality Metrics for Agricultural Chemical Usage

Purpose and Definitions: Under the guidance of the Statistical Policy Office of the Office of Management and Budget (OMB), NASS provides data users with quality metrics for its published data series. The metrics tables below describe the performance data for the survey contributing to the publication. The accuracy of data products may be evaluated through sampling and non-sampling error. The measurement of error due to sampling in the current period is evaluated by the coefficient of variation for each estimated item. Non-sampling error is evaluated by response rates and the percent of the estimate from respondents.

Sample Size is the number of observations selected from the population that are used to be representative of the entire population.

Response rates measure the proportion of the sample that is represented by the responding units in the survey.

Coefficient of Variation provides a measure of the size for the standard error relative to the point estimate and is used to measure the precision of the results of a survey estimator.

Fruit Chemical Usage, Sample Size, and Response Rate – Program States: 2019

State	Sample size	Response rate
	(number)	(percent)
California	2,405	64.3
Florida	519	28.3
Georgia	184	57.6
Michigan	610	50.3
New Jersey	139	38.8
New York	198	39.9
North Carolina	84	70.2
Oregon	499	51.9
Pennsylvania	248	53.2
South Carolina	62	43.5
Texas	94	67.0
Washington	909	39.4
Program States	5,951	52.7

Apples Pesticide Usage Coefficient of Variation – Program States: 2019

Active ingredient	Percent of acres treated	Number of applications	Rate per application	Rate per crop Year
	(CV percent)	(CV percent)	(CV percent)	(CV percent)
Herbicides				
2,4-D; dimethylamine salt	17	7	11	15
Carfentrazone-ethyl	24	6	11	12
Diuron	57	5	5	8
Glufosinate-ammonium	45	4	3	5
Glyphosate isopropylamine salt	14	5	6	9
Glyphosate potassium salt	32	8	23	25
Paraquat	32	6	6	11
Pendimethalin	29	4	8	9
Pyraflufen-ethyl	45	2	6	7
Rimsulfuron	17	1	4	5
Insecticides				
Abamectin	8	2	4	5
Acetamiprid	6	7	4	7
Beta-cyfluthrin	33	6	4	4
Carbaryl	14	4	8	8
Chlorantraniliprole	5	3	3	4
Chlorpyrifos	21	2	4	3
Clothianidin	10	5	3	7
Cyflumetofen	36	5	3	3
Diazinon	29	7	6	8
Emamectin benzoate	14	8	2	7
Esfenvalerate	22	7	5	11
Ethyl (2E;4Z) - decadienoate	15	12	6	12
Fenpropathrin	29	22	18	14
Imidacloprid	9	6	4	6
Indoxacarb	28	16	14	13
Kaolin	27	4	7	8
Lambda-cyhalothrin	9	6	2	6
Methoxyfenozide	26	7	6	5
Novaluron	25	8	3	10
Phosmet	15	5	9	9
Pyridaben	32	2	7	5
Pyriproxyfen	16	7	2	8
Spinetoram	4	4	1	4
Spinosad	21	7	3	9
Spirotetramat	22	18	2	16
Thiamethoxam	10	6	4	5
Zeta-cypermethrin	19	6	3	6

Apples Pesticide Usage Coefficient of Variation – Program States: 2019

Active ingredient	Percent of acres treated	Number of applications	Rate per application	Rate per crop Year
	(CV percent)	(CV percent)	(CV percent)	(CV percent)
Fungicides				
Basic copper sulfate				
Benzovindiflupyr	11	6	3	6
Boscalid	21	3	2	4
	17	7	4	7
Calcium polysulfide				
Captan	3	4	4	4
Copper chloride hydroxide	14	7	30	32
Copper hydroxide	13	5	14	16
Copper oxide	17	6	7	7
Cyprodinil	11	9	4	9
Difenoconazole	11	8	5	10
Dodine	16	8	6	7
Fenbuconazole	13	29	7	27
Fluopyram	10	7	1	6
Fluxapyroxad	11	9	3	7
Kasugamycin	26	7	4	5
Mancozeb	6	6	3	5
Mono-potassium salt	29	14	8	13
Myclobutanil	21	7	4	8
Oxytetracycline hydrochloride	30	6	2	6
Penthiopyrad	28	6	2	7
Pyraclostrobin	10	10	17	19
Pyrimethanil	17	6	3	5
Streptomycin sulfate	12	6	24	26
Sulfur	10	6	5	7
Thiophanate-methyl	13	8	9	9
Trifloxystrobin	7	5	2	5
Triflumizole	30	10	4	8
Ziram	21	13	9	9
Other Chemicals				
Acibenzolar-s-methyl	26	10	2	11
Aureobasidium pullulans	18	2	(N/A)	(N/A)
Benzyladenine	30	5	7	12
Butenoic acid hydrochloride	16	5	12	9
Cytokinins	28	5	5	8
Dodecadien-1-ol	22	4	14	16
Dodecano	18	1	5	5
Ethephon	10	7	7	6
Flutriafol	8	6	2	6
Gibberellins A4A7	15	7	20	15
Indaziflam	33	4	4	7
Mineral oil	5	14	13	8
NAA	27	13	15	21
NAA; Potassium salt	22	5	23	27
NAA; Sodium	16	9	14	18
NAD	22	6	16	22
Oxytetracycline hydrochloride	29	17	7	13
Prohexadione calcium	23	10	10	8
Spirodiclofen	13	7	1	7
Tetradecanol	18	1	5	5

(NA) Not available.

Apricots Pesticide Usage Coefficient of Variation – Program States: 2019

Active ingredient	Percent of acres treated	Number of applications	Rate per application	Rate per crop Year
	(CV percent)	(CV percent)	(CV percent)	(CV percent)
Other Chemicals				
Mineral oil	24	26	8	31

Avocados Pesticide Usage Coefficient of Variation – Program States: 2019

Active ingredient	Percent of acres treated	Number of applications	Rate per application	Rate per crop Year
	(CV percent)	(CV percent)	(CV percent)	(CV percent)
Herbicides				
Glyphosate isopropylamine salt	19	38	19	56
Glyphosate potassium salt	18	21	12	19
Insecticides				
Abamectin	12	9	2	9
Other Chemicals				
Gibberellic acid	29	21	9	30
Mineral oil	10	8	9	14

Blueberries Pesticide Usage Coefficient of Variation – Program States: 2019

Active ingredient	Percent of acres treated	Number of applications	Rate per application	Rate per crop Year
	(CV percent)	(CV percent)	(CV percent)	(CV percent)
Herbicides				
Clethodim	45	11	9	16
Diuron	21	5	13	15
Flumioxazin	14	21	13	14
Glufosinate-ammonium	12	56	33	88
Glyphosate isopropylamine salt	25	18	17	34
Mesotrione	17	2	8	9
Oryzalin	25	4	25	26
Paraquat	42	16	16	25
Simazine	21	39	20	30
Terbacil	30	37	18	28
Insecticides				
Acetamiprid	31	10	6	13
Bifenthrin	9	9	6	10
Diazinon	21	8	20	22
Esfenvalerate	34	13	2	13
Fenpropathrin	46	13	8	21
Imidacloprid	19	9	10	11
Malathion	23	7	11	11
Methomyl	31	12	4	13
Phosmet	10	7	6	11
Spinetoram	47	11	9	5
Zeta-cypermethrin	20	7	1	7
Fungicides				
Azoxystrobin	10	8	5	12
Boscalid	15	9	5	7
Calcium polysulfide	28	5	23	23
Captan	11	8	4	8
Chlorothalonil	28	35	25	12
Cyprodinil	25	9	4	10
Fenbuconazole	21	6	5	7
Fludioxonil	22	9	4	10
Fluopyram	19	9	5	11
Metconazole	21	14	7	15
Mono-potassium salt	22	20	14	18
Propiconazole	19	16	7	20
Prothioconazole	21	5	(Z)	5
Pyraclostrobin	34	8	6	7
Ziram	21	7	6	11
Other Chemicals				
Hydrogen peroxide	13	16	19	20
Peroxyacetic acid	18	17	23	24

(Z) Less than half of the unit shown.

Cherries, Sweet Pesticide Usage Coefficient of Variation – Program States: 2019

Active ingredient	Percent of acres treated	Number of applications	Rate per application	Rate per crop Year
	(CV percent)	(CV percent)	(CV percent)	(CV percent)
Herbicides				
2,4-D; dimethylamine salt	71	3	6	8
Flumioxazin	42	9	10	11
Glufosinate-ammonium	22	13	4	12
Glyphosate isopropylamine salt	17	7	6	8
Glyphosate potassium salt	25	32	10	29
Oryzalin	55	3	12	10
Oxyfluorfen	28	8	10	12
Paraquat	37	11	6	9
Pendimethalin	22	7	8	13
Pyraflufen-ethyl	16	9	4	10
Rimsulfuron	17	6	6	10
Insecticides				
Abamectin	22	15	7	17
Acetamiprid	29	8	6	12
Bifenazate	28	16	3	16
Buprofezin	15	6	(Z)	6
Chlorantraniliprole	23	8	3	10
Chlorpyrifos	14	2	1	3
Fenpropathrin	12	5	2	6
Imidacloprid	11	8	3	10
Lambda-cyhalothrin	12	12	1	12
Malathion	33	19	2	18
Pyriproxyfen	31	8	4	10
Spinetoram	12	6	1	6
Spinosad	13	8	5	6
Spinetoram	18	3	6	7
Thiamethoxam	36	10	11	17
Zeta-cypermethrin	18	23	2	23

Cherries, Sweet Pesticide Usage Coefficient of Variation – Program States: 2019

Active ingredient	Percent of acres treated	Number of applications	Rate per application	Rate per crop Year
	(CV percent)	(CV percent)	(CV percent)	(CV percent)
Fungicides				
Boscalid	9	5	1	4
Calcium polysulfide	22	10	9	9
Copper hydroxide	15	9	9	14
Copper oxide	22	8	5	4
Fluopyram	8	7	2	7
Fluxapyroxad	14	6	2	8
Kasugamycin	33	15	1	15
Myclobutanil	15	9	1	10
Penthiopyrad	24	8	2	7
Polyoxin D zinc salt	24	9	1	9
Potassium biocarbonate	27	12	2	12
Propiconazole	31	39	1	39
Pyraclostrobin	10	5	1	6
Quinoline	9	5	1	5
Sulfur	9	7	3	9
Tebuconazole	29	14	5	15
Thiophanate-methyl	56	10	7	15
Trifloxystrobin	9	9	2	9
Triflumizole	13	6	3	5
Other Chemicals				
Butenoic acid hydrochloride	19	4	6	7
Cyanamid	19	4	7	9
Cytokinins	19	12	2	12
Flutriafol	19	8	6	10
Gibberellic acid	10	5	8	10
Gibberellins A4A7	21	6	1	6
Harpin a B protein	33	19	(Z)	19
Indaziflam	23	6	4	7
Mineral oil	11	9	7	6
Prohexadione calcium	24	10	4	9
Spirodiclofen	28	8	1	8

(Z) Less than half of the unit shown.

Cherries, Tart Pesticide Usage Coefficient of Variation – Program States: 2019

Active ingredient	Percent of acres treated	Number of applications	Rate per application	Rate per crop Year
	(CV percent)	(CV percent)	(CV percent)	(CV percent)
Herbicides				
2,4-D; dimethylamine salt	46	12	19	28
Glyphosate isopropylamine salt	12	21	11	15
Insecticides				
Imidacloprid	19	14	15	28
Lambda-cyhalothrin	15	3	5	6
Phosmet	5	8	7	8
Thiamethoxam	12	6	4	5
Zeta-cypermethrin	19	6	4	10
Fungicides				
Captan	4	4	5	5
Chlorothalonil	3	13	5	13
Copper chloride hydroxide	24	18	19	12
Copper hydroxide	23	24	8	26
Dodine	15	10	12	8
Fenbuconazole	29	7	15	17
Fluopyram	40	6	3	8
Fluxapyroxad	26	14	8	21
Myclobutanil	43	16	11	14
Pyraclostrobin	26	14	8	21
Sulfur	18	38	25	17
Tebuconazole	42	26	4	26
Trifloxystrobin	22	8	10	8
Other Chemicals				
Ethephon	10	2	5	5
Gibberellic acid	18	11	27	20

Grapefruit Pesticide Usage Coefficient of Variation – Program States: 2019

Active ingredient	Percent of acres treated	Number of applications	Rate per application	Rate per crop Year
	(CV percent)	(CV percent)	(CV percent)	(CV percent)
Herbicides				
Glyphosate isopropylamine salt	32	34	32	7
Glyphosate potassium salt	64	28	20	44
Saflufenacil	34	25	22	11
Insecticides				
Abamectin	17	32	7	28
Beta-cyfluthrin	79	19	30	30
Chlorpyrifos	69	20	13	18
Cyantraniliprole	43	16	10	14
Diflubenzuron	31	46	19	28
Fenbutatin-oxide	34	18	22	38
Fenpropathrin	20	66	7	72
Imidacloprid	24	20	37	27
Pyridaben	18	23	8	27
Spinetoram	45	33	4	32
Spirotetramat	30	11	10	6
Sulfur	57	52	31	34
Thiafloxystrobin	30	20	11	14
Fungicides				
Azoxystrobin	49	12	29	38
Copper hydroxide	10	48	4	47
Difenoconazole	84	39	56	95
Fenbuconazole	38	11	23	28
Pyraclostrobin	38	12	9	8
Other Chemicals				
Indaziflam	17	13	8	13
Mineral oil	20	28	21	17
Spirodiclofen	69	45	14	52

Grapes, All Pesticide Usage Coefficient of Variation – Program States: 2019

Active ingredient	Percent of acres treated	Number of applications	Rate per application	Rate per crop Year
	(CV percent)	(CV percent)	(CV percent)	(CV percent)
Herbicides				
Carfentrazone-ethyl	22	16	12	18
Glufosinate-ammonium	17	14	5	12
Glyphosate isopropylamine salt	21	10	9	15
Glyphosate potassium salt	15	29	15	16
Oryzalin	32	49	16	39
Oxyfluorfen	18	26	11	21
Paraquat	30	12	4	14
Pyraflufen-ethyl	28	18	13	13
Rimsulfuron	15	27	11	18
Insecticides				
Buprofezin	23	22	7	22
Chlorantraniliprole	20	16	7	15
Cyflumetofen	54	23	7	28
Etoxazole	31	13	21	22
Imidacloprid	21	8	14	14
Methoxyfenozide	32	22	22	12
Spirotetramat	14	9	2	10
Thiamethoxam	16	17	4	18
Fungicides				
Azoxystrobin	14	23	7	23
Copper chloride hydroxide	19	16	29	20
Copper hydroxide	15	11	12	13
Copper oxide	26	12	11	9
Cyflufenamid	18	14	2	14
Cyprodinil	20	17	6	13
Difenoconazole	23	17	3	17
Fenbexamid	24	17	7	14
Fludioxonil	20	12	14	18
Fluopyram	15	12	3	11
Kresoxim-methyl	21	15	8	17
Myclobutanil	14	9	10	5
Polyoxin D zinc salt	29	28	30	32
Quinoline	14	9	3	9
Sulfur	13	11	10	20
Tebuconazole	10	12	6	12
Tetraconazole	21	11	3	13
Trifloxystrobin	16	18	5	18
Triflumizole	22	24	7	29
Other Chemicals				
Ethephon	27	6	21	22
Gibberellic acid	10	21	22	23
Indaziflam	19	34	17	18
Lavandulyl senecioate	40	26	34	41
Metrafenone	23	14	2	13
Mineral oil	13	17	8	22

Grapes, Raisin Pesticide Usage Coefficient of Variation – Program States: 2019

Active ingredient	Percent of acres treated	Number of applications	Rate per application	Rate per crop Year
	(CV percent)	(CV percent)	(CV percent)	(CV percent)
Herbicides				
Glufosinate-ammonium	21	18	7	16
Glyphosate potassium salt	45	18	5	18
Oxyfluorfen	12	3	33	31
Insecticides				
Abamectin	28	13	19	25
Imidacloprid	19	23	38	32
Spirotetramat	18	11	7	15
Fungicides				
Copper hydroxide	20	21	18	18
Myclobutanil	24	15	8	14
Quinoline	20	29	4	29
Sulfur	3	21	8	22
Trifloxystrobin	38	37	3	36
Other Chemicals				
Gibberellic acid	22	29	19	31

Grapes, Table Pesticide Usage Coefficient of Variation – Program States: 2019

Active ingredient	Percent of acres treated	Number of applications	Rate per application	Rate per crop Year
	(CV percent)	(CV percent)	(CV percent)	(CV percent)
Herbicides				
Glufosinate-ammonium	38	9	13	13
Insecticides				
Imidacloprid	23	20	40	33
Spinetoram	27	10	27	18
Spirotetramat	26	3	16	14
Fungicides				
Copper hydroxide	45	17	13	12
Myclobutanil	31	39	56	20
Sulfur	3	16	11	14
Other Chemicals				
Gibberellic acid	13	28	31	33

Grapes, Wine Pesticide Usage Coefficient of Variation – Program States: 2019

Active ingredient	Percent of acres treated	Number of applications	Rate per application	Rate per crop Year
	(CV percent)	(CV percent)	(CV percent)	(CV percent)
Herbicides				
Carfentrazone-ethyl	22	16	13	18
Glufosinate-ammonium	22	17	5	14
Glyphosate isopropylamine salt	21	11	9	18
Paraquat	48	15	3	15
Pyraflufen-ethyl	33	25	14	19
Rimsulfuron	18	32	11	23
Insecticides				
Imidacloprid	29	12	10	17
Methoxyfenozide	47	20	7	19
Spirotetramat	24	14	2	14
Thiamethoxam	16	17	4	18
Fungicides				
Azoxystrobin	13	27	8	29
Copper chloride hydroxide	34	26	34	32
Copper hydroxide	16	18	15	19
Cyflufenamid	22	17	2	17
Cyprodinil	25	20	2	21
Difenoconazole	27	23	1	23
Fluopyram	18	13	3	12
Kresoxim-methyl	25	26	4	22
Myclobutanil	22	9	5	10
Polyoxin D zinc salt	36	35	2	35
Quinoline	16	10	3	10
Sulfur	19	15	11	24
Tebuconazole	12	15	3	14
Tetraconazole	24	12	4	15
Trifloxystrobin	24	22	3	22
Triflumizole	33	46	2	47
Other Chemicals				
Metrafenone	27	17	2	16
Mineral oil	13	19	8	24

Lemons Pesticide Usage Coefficient of Variation – Program States: 2019

Active ingredient	Percent of acres treated	Number of applications	Rate per application	Rate per crop Year
	(CV percent)	(CV percent)	(CV percent)	(CV percent)
Herbicides				
Glufosinate-ammonium	67	4	36	36
Glyphosate potassium salt	52	46	11	51
Glyphosate isopropylamine salt	30	40	5	36
Rimsulfuron	31	8	9	15
Saflufenacil	54	35	31	65
Insecticides				
Abamectin	18	17	2	18
Beta-cyfluthrin	18	26	19	45
Cyantraniliprole	45	9	6	7
Fenpropathrin	32	8	4	4
Flupyradifurone	44	7	4	10
Imidacloprid	15	10	3	9
Pyriproxyfen	58	7	6	4
Spinetoram	34	13	2	13
Spirotetramat	34	9	2	10
Thiamethoxam	29	10	4	7
Zeta-cypermethrin	72	15	1	15
Fungicides				
Basic copper sulfate	23	12	6	9
Copper hydroxide	37	29	9	30
Other Chemicals				
2,4-D, isopropyl ester	48	16	6	10
Gibberellic acid	34	21	12	31
Indaziflam	33	15	3	13
Metaldehyde	70	3	17	17
Mineral oil	13	21	16	13

Nectarines Pesticide Usage Coefficient of Variation – Program States: 2019

Active ingredient	Percent of acres treated	Number of Applications	Rate per application	Rate per crop Year
	(CV percent)	(CV percent)	(CV percent)	(CV percent)
Herbicides				
Glufosinate-ammonium	40	18	10	16
Insecticides				
Spinetoram	27	14	4	16
Fungicides				
Iprodione	33	16	7	16
Propiconazole	30	13	3	12
Sulfur	27	15	7	15
Ziram	6	5	4	6
Other Chemicals				
E-8-Dodecenyl acetate	9	5	51	50
Mineral oil	8	10	14	17
Z-8-Dodecanol	9	5	52	50
Z-8-Dodecen acetate	9	5	48	46

Olives Pesticide Usage Coefficient of Variation – Program States: 2019

Active ingredient	Percent of acres treated	Number of applications	Rate per application	Rate per crop Year
	(CV percent)	(CV percent)	(CV percent)	(CV percent)
Insecticides				
Spinosad	48	14	21	28
Fungicides				
Copper hydroxide	49	15	9	9

Oranges Pesticide Usage Coefficient of Variation – Program States: 2019

Active ingredient	Percent of acres treated	Number of applications	Rate per application	Rate per crop Year
	(CV percent)	(CV percent)	(CV percent)	(CV percent)
Herbicides				
2,4-D; isopropylamine salt	43	16	6	15
Diuron	43	11	5	9
Glufosinate-ammonium	38	23	16	27
Glyphosate isopropylamine salt	9	22	12	25
Glyphosate potassium salt	36	11	19	18
Paraquat	55	30	44	18
Rimsulfuron	26	25	12	16
Saflufenacil	38	36	4	37
Insecticides				
Abamectin	5	24	15	17
Acetamiprid	24	12	4	12
Beta-cyfluthrin	37	7	2	7
Buprofezin	39	27	1	27
Chlorpyrifos	53	21	66	54
Chlorantraniliprole	12	18	2	18
Cyflumetofen	39	24	1	24
Diflubenzuron	39	24	19	30
Fenpropathrin	61	38	7	43
Fenpyroximate	51	37	15	50
Flupyradifurone	60	72	11	83
Formetanate hydrochloride	23	25	2	25
Imidacloprid	16	7	23	26
Malathion	32	9	18	10
Spirotetramat	48	26	13	27
Sulfur	35	34	10	34
Thiamethoxam	15	11	7	12
Zeta-cypermethrin	37	21	7	22
Fungicides				
Azoxystrobin	58	10	11	15
Basic copper sulfate	15	23	18	21
Copper hydroxide	11	17	19	25
Difenoconazole	32	22	6	24
Mefenoxam	47	18	50	65
Pyraclostrobin	39	7	22	26
Other Chemicals				
2,4-D, isopropyl ester	7	27	8	23
Indaziflam	19	12	3	13
Metaldehyde	17	40	9	37
Mineral oil	7	16	25	21
Spirodiclofen	44	15	6	20

Peaches Pesticide Usage Coefficient of Variation – Program States: 2019

Active ingredient	Percent of acres treated	Number of applications	Rate per application	Rate per crop Year
	(CV percent)	(CV percent)	(CV percent)	(CV percent)
Herbicides				
2,4-D; dimethylamine salt	38	13	15	25
Glufosinate-ammonium	23	15	6	18
Glyphosate isopropylamine salt	17	22	6	27
Glyphosate potassium salt	30	7	11	17
Oxyfluorfen	19	26	23	14
Paraquat	21	25	21	20
Pendimethalin	25	18	6	21
Rimsulfuron	20	13	4	15
Insecticides				
Abamectin	19	6	5	9
Acetamiprid	58	34	9	42
Beta-cyfluthrin	33	19	10	11
Chlorantraniliprole	14	10	1	10
Chlorpyrifos	16	40	29	25
Esfenvalerate	15	15	8	22
Fenpropathrin	32	20	12	30
Imidacloprid	74	19	30	29
Indoxacarb	56	27	4	30
Lambda-cyhalothrin	23	20	3	22
Methoxyfenozide	21	15	3	14
Permethrin	39	32	15	35
Phosmet	46	18	9	11
Spinetoram	42	28	5	28
Thiamethoxam	53	7	10	6
Zeta-cypermethrin	32	168	45	124
Fungicides				
Azoxystrobin	34	49	11	38
Basic copper sulfate	26	9	33	27
Boscalid	54	48	3	51
Captan	16	15	24	14
Chlorothalonil	28	15	7	18
Copper chloride hydroxide	67	16	29	15
Copper hydroxide	24	18	39	49
Cyprodinil	8	10	13	8
Fenbuconazole	47	19	12	25
Fluopyram	33	17	24	30
Fluxapyroxad	33	19	5	22
Iprodione	21	36	6	40
Myclobutanil	23	25	8	24
Oxytetracycline calcium	84	36	40	24
Penthiopyrad	40	7	3	5
Propiconazole	8	14	5	13
Pyraclostrobin	32	27	4	30
Sulfur	31	27	17	43
Tebuconazole	27	20	4	19
Thiophanate-methyl	46	20	11	20
Trifloxystrobin	32	14	6	17
Ziram	6	14	4	16
Other Chemicals				
E-8-Dodecenyl acetate	32	40	38	74
Indaziflam	30	7	9	8
Mineral oil	15	18	18	29
Z-8-Dodecanol	32	40	65	59
Z-8-Dodecen acetate	32	40	146	184

Pears Pesticide Usage Coefficient of Variation – Program States: 2019

Active ingredient	Percent of acres treated	Number of applications	Rate per application	Rate per crop Year
	(CV percent)	(CV percent)	(CV percent)	(CV percent)
Herbicides				
2,4-D; dimethylamine salt	24	7	9	13
Glyphosate isopropylamine salt	13	7	6	9
Insecticides				
Abamectin	11	5	4	6
Acetamiprid	14	16	1	16
Azadirachtin	14	13	5	14
Chlorantraniliprole	20	9	4	9
Kaolin	16	9	7	12
Lambda-cyhalothrin	20	7	5	8
Malathion	32	4	(Z)	4
Novaluron	19	6	2	6
Pyridaben	11	2	6	7
Pyriproxyfen	16	6	(Z)	6
Spinetoram	15	11	1	12
Spirotetramat	6	10	1	10
Thiamethoxam	24	11	4	8
Tolfenpyrad	14	6	(Z)	6
Fungicides				
Basic copper sulfate	18	5	5	9
Calcium polysulfide	22	24	8	25
Copper hydroxide	21	13	26	16
Cyprodinil	30	20	13	15
Difenoconazole	31	17	13	15
Fluopyram	15	4	3	5
Fluxapyroxad	20	2	2	3
Kasugamycin	20	4	(Z)	4
Mancozeb	7	7	4	5
Oxytetracycline calcium	38	19	17	12
Penthiopyrad	11	4	2	4
Pyraclostrobin	17	11	11	16
Streptomycin sulfate	13	24	8	20
Sulfur	11	13	2	14
Thiophanate-methyl	32	4	(Z)	4
Trifloxystrobin	16	4	2	6
Triflumizole	23	10	4	9
Other Chemicals				
Benzyladenine	30	6	10	7
Dodecadien-1-ol	22	8	20	21
Dodecanol	27	14	10	22
Mineral oil	5	7	8	10
NAA; Potassium salt	15	9	4	10
Oxytetracycline hydrochloride	12	27	6	25
Spirodiclofen	22	21	1	21
Tetradecanol	27	14	9	21

(Z) Less than half of the unit shown.

Plums Pesticide Usage Coefficient of Variation – Program States: 2019

Active ingredient	Percent of acres treated	Number of applications	Rate per application	Rate per crop Year
	(CV percent)	(CV percent)	(CV percent)	(CV percent)
Herbicides				
Glufosinate-ammonium	39	12	16	10
Oxyfluorfen	35	10	26	32
Rimsulfuron	30	14	8	14
Insecticides				
Esfenvalerate	27	21	5	24
Fungicides				
Propiconazole	27	11	54	57
Other Chemicals				
Mineral oil	16	20	10	29

Prunes Pesticide Usage Coefficient of Variation – Program States: 2019

Active ingredient	Percent of acres treated	Number of applications	Rate per application	Rate per crop Year
	(CV percent)	(CV percent)	(CV percent)	(CV percent)
Herbicides				
Glufosinate-ammonium	23	5	10	11
Glyphosate isopropylamine salt	17	28	18	13
Glyphosate potassium salt	16	12	11	14
Oxyfluorfen	17	12	40	37
Insecticides				
Esfenvalerate	9	3	4	4
Fungicides				
Chlorothalonil	16	5	2	5
Propiconazole	10	9	4	7
Other Chemicals				
Indaziflam	20	5	8	11
Mineral oil	15	7	19	17

Strawberries Pesticide Usage Coefficient of Variation – Program States: 2019

Active ingredient	Percent of acres treated	Number of applications	Rate per application	Rate per crop Year
	(CV percent)	(CV percent)	(CV percent)	(CV percent)
Insecticides				
Abamectin	23	18	27	38
Acequinocyl	25	15	1	16
Acetamiprid	19	9	2	9
Bifenazate	19	17	9	17
Bifenthrin	17	26	5	26
Chlorantraniliprole	19	11	5	9
Cyflumetofen	20	13	1	13
Fenpropathrin	26	19	7	25
Flonicamid	12	12	2	12
Flupyradifurone	24	20	13	25
Novaluron	17	27	18	14
Spinetoram	17	6	8	11
Thiamethoxam	21	25	2	26
Fungicides				
Azoxystrobin	27	24	29	47
Boscalid	28	19	6	17
Captan	8	19	5	22
Cyprodinil	17	7	2	8
Fludioxonil	17	7	2	8
Fluopyram	14	20	6	16
Polyoxin D zinc salt	33	23	39	47
Quinoline	24	23	(Z)	23
Thiram	18	19	7	15
Trifloxystrobin	14	17	4	15

(Z) Less than half of the unit shown.

Tangerines Pesticide Usage Coefficient of Variation – Program States: 2019

Active ingredient	Percent of acres treated	Number of applications	Rate per Application	Rate per crop Year
	(CV percent)	(CV percent)	(CV percent)	(CV percent)
Herbicides				
Glyphosate isopropylamine salt	19	26	15	28
Rimsulfuron	69	30	12	18
Insecticides				
Abamectin	21	36	6	33
Buprofezin	28	19	(Z)	19
Cyantraniliprole	29	46	3	47
Fenpropathrin	47	16	11	19
Fenpyroximate	37	26	1	27
Imidacloprid	70	40	4	40
Pyriproxyfen	27	26	4	23
Spirotetramat	21	16	4	16
Thiamethoxam	46	24	11	33
Fungicides				
Azoxystrobin	44	20	4	19
Copper hydroxide	16	19	12	20
Pyraclostrobin	29	27	4	30
Other Chemicals				
2,4-D; isopropyl ester	45	25	3	24
Indaziflam	52	25	8	32
Metaldehyde	39	13	14	24
Mineral oil	25	28	17	32

(Z) Less than half of the unit shown.

Information Contacts

Process	Unit	Telephone	Email
Estimation	Environmental Economics and Demographics	(202) 720-4447	HQ_SD_EEDB-EDS@nass.usda.gov
Data Collection	Survey Administration Branch	(202) 690-3692	HQ_CSD_SAB@nass.usda.gov
Questionnaires	Data Collection Branch	(202) 720-8646	HQ_CSD_DCB@nass.usda.gov
Sampling and Editing	Sampling Editing and Imputation Methodology Branch	(202) 720-5805	HQ_MD_SEIMB-Staff@nass.usda.gov
Summary and Estimators	Summary Estimation and Disclosure Methodology Branch	(202) 690-0270	HQ_MD_SEIMB-Staff@nass.usda.gov
Dissemination	Data Dissemination Office	(202) 720-3400	HQOAPAO@nass.usda.gov
Media Contact and Webmaster	Public Affairs Office	(202) 720-2639	HQOAPAO@nass.usda.gov

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