Standard Operating Procedure (SOP)

Science Advisory Council for Exposure (ExpoSAC)
Health Effects Division (HED)
Office of Pesticide Programs (OPP)

Policy Number: 15.2

Regarding: Standard Values for Amount of Seed Treated and/or Planted Per Day

Date: January 2022

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Executive Summary

This revision of Policy 15 ensures that consistent standard values are used to calculate the amount of seed treated and the amount of seed planted per day for commercial and on-farm seed treatment scenarios. The standard values in this SOP are based on information obtained from OPP's Biological and Economic Analysis Division (BEAD) and the Agricultural Handler Exposure Task Force (AHETF). If refinements are needed, these values may be modified by chemical-specific information. Such refinements require consultation with the appropriate staff from BEAD.

In general, HED uses the term handlers to describe those individuals who are involved in the pesticide application process, and the term post-application to describe exposures that occur when individuals are present in an environment that has been previously treated with a pesticide (also referred to as re-entry exposure). HED believes that there are distinct job functions or tasks related to pesticide applications, and exposures can vary depending on the specifics of each task. For seed treatment assessment, HED considers both the treatment of seed and the planting of treated seed to be handler scenarios (primary and secondary handlers, respectively) and thus subject to any applicable pesticide 'handler' regulations. Both activities are part of the pesticide application process for seed treatment. The potential for post-application exposures following the planting of treated seeds is unlikely because sustained levels of contact with treated seed after it has been placed in the soil or other planting media would not be expected because no routine cultural practice required for the production of agricultural commodities involves such an activity, as defined in the no/low contact criteria in the Worker Protection Standard (WPS).

This SOP is divided into the following sections:

1. Amount of Seed Treated
2. Amount of Seed Planted
3. Planting Transplants Grown from Treated Seed
4. Glossary

Note: Glossary terms are identified throughout the document via hyperlinks to the glossary section.

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1.0 Introduction

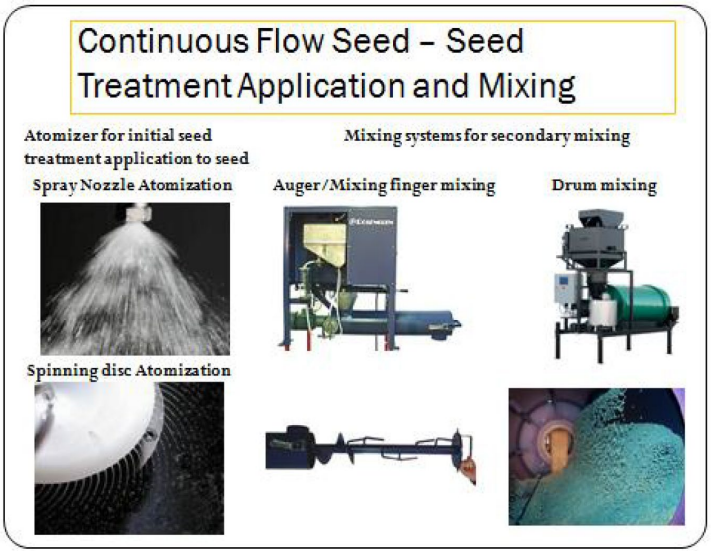
This revision of Policy 15 ensures that consistent standard values are used to calculate the amount of seed treated and the amount of seed planted per day for commercial and on-farm seed treatment scenarios.

Historically, high volume seeding practices were used to compensate for crop field mortality. Now, farmers seek methods to cut costs while still obtaining high yields. As agricultural practices advance, seed treatment is a viable and cost-effective option for crop protection. Seed treatment prevents the spread of pests and soilborne pathogens, protecting the seed from initial infections, thereby systemically protecting the entire plant.

There are multiple venues for treating seeds, including large commercial companies, smaller downstream companies, and local on-farm businesses. Commercial seed treatment companies are seed producers that own or license their own seed lines, and provide seed enhancement services in addition to seed treatment. Downstream seed treatment companies obtain cleaned and ready-for-planting processed seed from other sources such as seed producers, seed breeders, and growers. These companies include retailers, distributors, and agricultural cooperatives. On-farm businesses treat batches locally on a per order basis. For additional clarification and definitions of the various terminologies used in seed treatment practices, see the glossary in Appendix A.

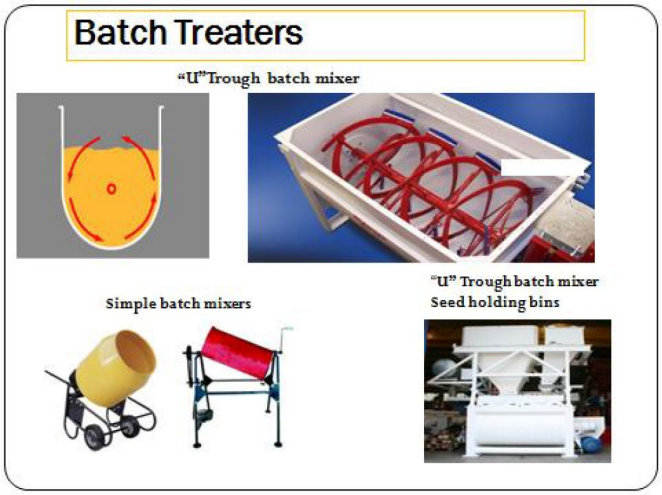
Commercial seed treatment can involve three different seed treater types:

1. Continuous flow treaters which treat a steady flow of untreated seed with the seed treatment product (photos copied from AHETF 2014[1]);



[1] Agricultural Handler Exposure Scenario Monograph for Commercial Seed Treatment Scenarios. Report Number AHE1008. March 2014.

2. Batch treaters which treat a single batch (or given amount of seed) at a time (photos copied from AHETF 2014[1]); or



3. Continuous batch treaters which are a combination of a continuous flow and a batch treater, utilizing seed from a steady flow of untreated seed, and treating the seed in batches until the seed source is depleted or a predetermined number of batches are treated (photos copied from AHETF 2014[1]).

In commercial seed treatment facilities, seed is professionally treated and packaged in small bags, mini-bulk containers (e.g., bins or large bags), or loose bulk containers (e.g., seed wagons or trucks), and then delivered later to growers (photos copied from AHETF 2014[2]).

[2] Agricultural Handler Exposure Scenario Monograph for Commercial Seed Treatment Scenarios. Report Number AHE1008. March 2014.

Downstream facilities process much of their seed as loose bulk, where treated seed is conveyed into a grower's truck or wagon directly from the treater. This is distinctly different from on-farm seed treating where seed is treated more locally (e.g., at a specific farm), and planted without bagging. All on-farm seed treatment systems have a method to transfer and treat clean untreated seed from bulk storage to a seed wagon or truck, or from a truck or wagon to the planter.

On-farm seed treatment generally involves workers that operate any on-farm seed treating equipment, including mixing, loading and application of a pesticide to untreated seed, and any associated tasks such as maintaining the treating equipment and planting the treated seed. This scenario applies to any seed type labeled for on-farm seed treatment. Treating equipment for this scenario includes both open and closed systems. On-farm seed treating equipment typically involves some type of mechanical conveying or augering system that accommodates treatment as the seed is moved into equipment such as a seed truck (such as for transport to the field), onto a conveyor (such as for transport into temporary storage), or directly into a planter. All on-farm seed treaters are continuous flow treaters, meaning the seed treatment process continues until the

seed supply is depleted. On-farm systems are manual in design and require an operator to stop and start the seed treating process (photos copied from AHETF 2014[3]).

The potential for exposure from seed treatment can be divided into two main categories: treating seed and planting seed. Within the treating seed category, potential exposure scenarios can include mixing, loading, applying formulations; bagging treated seed (for commercial seed treatment only); sewing bags (for commercial seed treatment only); and other activities, such as cleaning and calibrating treatment equipment. Within the planting seed category, potential exposure only includes the planting of treated seed. Typically, planting treated seed consists of the farmer purchasing treated seed, placing treated seed in a hopper, and applying treated seed to fields.

[3] Agricultural Handler Exposure Scenario Monograph for Commercial Seed Treatment Scenarios. Report Number AHE1008. March 2014.

For commercial seed treatment, depending on seed type, exposure duration may vary between short-, and intermediate--term. For on-farm seed treatment, the exposure duration is anticipated to be short-term only.

For both commercial and on-farm seed treatment, handler exposure can be calculated with the following equation:

$$Dose = \frac{UE \times AR \times AST}{BW}$$

Where:

UE	=	Unit Exposure (mg/lb ai), task-specific (see ExpoSAC Policy #14)
AR	=	Application Rate (lb ai/lb seed)
AST	=	Amount of Seed Treated per Day (lb seed/day)
BW	=	Body Weight (kg)

For planting of treated seed, handler exposure can be calculated with the following equation:

$$Dose = \frac{UE \times AR \times ASP}{BW}$$

Where:

UE	=	Unit Exposure (mg/lb ai)
AR	=	Application Rate (lb ai/lb seed)
ASP	=	Amount of Seed Planted per Day (lb seed/day)
BW	=	Body Weight (kg)

Note: If *Application Rate* is provided in *mg ai/seed*, the following equation can be used to convert the application rate to lb ai/lb seed.

$$AR_{lb\ ai/lb\ seed} = AR_{mg\ ai/seed} \times SC \times CF$$

Where:

$AR_{lb\ ai/seed}$	=	Application Rate (lb ai/lb seed)
$AR_{mg\ ai/seed}$	=	Application Rate (mg ai/seed)
SC	=	Seed Count (# seeds/lb seed)
CF	=	Conversion Factor (1 lb ai = 454,000 mg ai)

Seed count information (# seeds/lb seed) can be found in the BEAD memo "Acres Planted Per Day and Seeding Rates of Crops Grown in the United States" (J. Becker, March 2011).

The unit exposure (UE) inputs for the exposure calculations are provided in ExpoSAC Policy 14. The amount of seed treated (AST) and amount of seed planted (ASP) are provided in this document.

2.0 Amount of Seed Treated (AST)

2.1 Commercial Seed Treatment

For most seed types that are treated commercially, the AST per day is primarily driven by equipment capacity. In this approach, the AST is determined by assuming that the equipment is operated at full capacity continuously during an 8-hour workday. The primary source of information on the amount of seed treated commercially per day is provided by the AHETF[4]. The information was collected from surveys which provide daily seed treatment throughput data along with information on seed treating equipment and worker activities. These surveys were reviewed and the methods were found to be acceptable (D343375[5]).

In the first phase of the survey, data were collected for the following five major crops: (1) canola, (2) corn, (3) rice, (4) soybean, and (5) wheat. The second phase collected data for the following three additional crops: (1) cotton, (2) peanut, and (3) sunflower.

The AHETF surveys were conducted in the United States and Canada in both commercial and downstream facilities. The AHETF surveys also include information about seed treatment duration, both in number of hours worked per day and number of days worked per year. The design and data collection of the surveys dictate how the resulting data can be utilized.

All else equal, because the surveys indicate commercial seed treatment facilities have higher throughput than downstream treatment facilities, HED assumes that the commercial seed treatment risk assessment is protective of downstream seed treatment. Thus, a separate risk assessment is not required for the downstream facilities.

Information in the survey is provided for both normal production periods and peak periods of seed treatment. A normal production period is defined as the period when the treatment line(s) of the facility are fully operational and operating at a normal or typical level. This period does not include peak periods or the beginning or ending of the season (i.e., the start-up or wind-down time). The peak production period is defined as the period when the treatment line(s) of the facility are operating at a maximum level – for example, when there are maximum orders and the operation needs to run up to 24 hours a day. Peak production throughput is about two times higher than normal production throughput for most facility and seed types.

Short- and intermediate-term exposures are expected for seed treatment. Long-term exposures are not anticipated. While the AHETF survey provided information on the length of the seed treatment season, the duration of treating that was captured represents the total number of days the facilities treated seed. It does not represent the total number of days that a specific active ingredient may be used nor does it represent the actual number of days that a worker may be involved in the seed treatment during that season. It is not considered likely that one active ingredient would be used every day for the entire treating season. For these reasons, long-term exposure is not anticipated for seed treatment and is not assessed.

Exposures resulting from seed treatment activities (e.g., loading/applying) <30 days are considered short-term exposures for which the 75th percentile values of the *typical* throughput

[4] MRID 49185401. Survey Results of Commercial and Downstream Seed Treating Facilities. Study Number AHE149. July 23, 2013. Agricultural Handler Exposure Task Force.
[5] Memo, D343375, Seed Treatment – Review of "Survey Results of Commercial and Downstream Seed Treating Facilities".

days during *peak* season are recommended to provide an appropriately health-protective short-term exposure estimate.

Exposures lasting 30 to 180 days are considered intermediate-term exposures, for which the 75th percentile values of the *typical* throughput days during *normal* season are recommended to provide an appropriately health-protective intermediate-term exposure estimate.

Since the AHETF surveys only include information for eight major field crops, throughput values for non-surveyed crops are assigned based on consultation with BEAD, including consideration of similarity of seed size to that of the surveyed crops and general knowledge of each crop and its production. These extrapolations do not apply for crops that are produced from "seed pieces" (e.g., potatoes). Information for these crops was collected from open literature and agricultural extension agents.

Vegetable crops are divided into two groups based on seed size. Based on information from the AHETF[6], there are no exact definitions, but it is generally agreed that vegetables with 10,000 or more seeds per pound are small seeded vegetables and those with 5,000 or less seeds per pound are large seeded vegetables. Appendix A provides examples of crops which are considered small seeded and large seeded vegetables. The 2013 AHETF survey was used to extrapolate the amount of seed treated for large-seeded vegetables.

The AHETF provided information[6] about the treatment of small-seeded vegetables, including a survey of a limited number of treatment facilities. Essentially, all small-seeded vegetable seeds receive some sort of treatment or enhancement (e.g., priming or film-coating). Seed treatments in general are moving away from dusts and slurry treatments, and towards film-coating and other seed enhancement technologies including encrusting and pelletizing. The goals of these modern seed treatments are to (1) minimize dust, (2) increase flowability in the seed planter equipment, and (3) obtain a good visual appearance of the finished product.

Although one or more enhancement processes (priming, film-coating, encrusting, pelleting) are used on virtually all small seeded vegetable seeds, many seeds are not treated with any chemical plant protection products. Overall, there are relatively few active ingredients and products being developed by chemical manufacturers for the treatment of small seeded vegetable seeds.

Two of the most common seed enhancements include film-coating and pelletizing. *Film-coating* puts a very thin colored film around the seed, increasing the seed's weight by about 5%, without changing its original size or shape. *Pelletizing* turns a lightweight and oddly shaped seed into a heavier, more uniform, perfectly rounded seed pellet, enabling a more precise and efficient mechanical seed planting. Depending on seed type and process, the weight of a pelletized seed can increase from 5-100 times the original seed weight.

Seed treatments vary by region and all small seeded vegetable seeds are custom treated based on individual customer requests. Because of the relatively small quantity of small seeded vegetable seed that is coated and treated by each seed treatment company and the wide variety of special

[6] Small Seeded Vegetable Use and Usage Report. Report No. AHE189. November 22, 2010. Agricultural Handler Exposure Task Force.

enhancements that the coatings must provide, the costs associated with treatment of small seeded vegetables is much higher than that of other crops. Most individual coating and treating orders for small seeded vegetable seeds involve very low quantities of seed.

Table 2.1.1 provides the recommended daily seed treatment values for several crops based on duration of exposure.

Table 2.1.1. Recommended Values for Amount of Seed Treated (AST) Per Day: Commercial and Downstream Seed Treatment Facilities.			
Surveyed Crops	Lbs of Seed Treated per 8-hr Work Shift[1]		Basis and Comments
	Short-Term[2]	Intermediate-Term[3]	
Alfalfa[4]	125,000	125,000	Daily throughput values are based on surveyed values for canola. Canola was selected to represent alfalfa because it has the most similar seed size among the surveyed crops. Over 20 million acres of alfalfa is harvested annually in the United States (USDA 2007). Assuming that this crop is rotated every 3 to 5 years, approximately 4 to 7 million acres are planted yearly.
Beets, sugar[4]	3,000	3,000	Sugar beets are not considered vegetables by the USDA, however, limited information is available on sugar beet seed treatment. Therefore, data available for small seeded vegetables was used as a surrogate. The value recommended is based on general information collected by the AHETF (2010) from a small number of facilities (exact number not reported) that film-coat small seeded vegetables.
Canola	125,000	125,000	Treatment facilities for this crop were surveyed (AHETF 2013). Survey indicates that 98% of canola is treated in commercial facilities (remaining 2% is not treated). The survey reports that commercial facilities in the US and Canada (data not provided separately for the US) operate 130 days per year (50th percentile; range 72 to 169 days).
Corn (field)	339,500	240,000	Treatment facilities for this crop were surveyed (AHETF 2013). Survey indicates that 98% of field corn is treated in commercial facilities (remaining 2% is not treated). The survey reports that commercial facilities operate 195 days per year (50th percentile; range 83 to 247 days).
Cotton	125,000	110,000	Treatment facilities for this crop were surveyed (AHETF 2013). Survey indicates that 98% of cotton is treated in commercial facilities (remaining 2% is not treated). It also indicates that 66% of the cotton crop is also treated at downstream facilities. The survey reports that commercial facilities operate 173 days per year (50th percentile; range 78 to 199 days). Note: Duration of downstream treatment is reported as 61 days (50th percentile; range 17 to 130 days).
Large Seeded Vegetable[4,6]	339,500	240,000	Daily throughput values are based on surveyed values for field corn. This crop was selected to represent all large seeded vegetables because it has the most similar seed size among the surveyed crops.
Peanuts	126,000	105,000	Treatment facilities for this crop were surveyed (AHETF 2013). Survey indicates that 98% of peanut seeds are treated in commercial facilities (remaining 2% is not treated). The survey reports that commercial facilities operate 65 days per year (50th percentile; range 41 to 104 days).

Table 2.1.1. Recommended Values for Amount of Seed Treated (AST) Per Day: Commercial and Downstream Seed Treatment Facilities.			
Surveyed Crops	Lbs of Seed Treated per 8-hr Work Shift[1]		Basis and Comments
	Short-Term[2]	Intermediate-Term[3]	
Potato[5]	800,000 (8,000 cwt[5])	400,000 (4,000 cwt)	Daily throughput values from the National Potato Council (2011) are based on information for typical potato seed piece treatment equipment (Milestone), and are as follows: Average throughput = 3,000 cwt (Milestone liquid treater 5 cwt per minute * 60 minutes per hour * 10 hours per day). Maximum throughput = 4,800 cwt (Milestone liquid treater 5 cwt per minute * 60 minutes per hour * 16 hours per day). Milestone potato cutters have performance standards of 150 to 550 cwt per hour (1,200 to 4,400 cwt per 8-hr workday) depending on the equipment model. The most commonly used cutters (Model 60D and 72D) have average throughput capacities of 400 and 550 cwt per hour. Milestone liquid treaters / dusters have average throughput capacity of 250 to 1,000 cwt per hour (2,000 to 8,000 cwt per 8-hr workday). Over the last 8 to 10 years, more liquid treatment equipment has been sold. The reported throughput values are based on the equipment operating normally and this rate can be maintained for an entire workday (Milestone 2010, 2012). Seed potatoes can be precut and treated and then held for several days to several weeks prior to planting (Bohl and Johnson, 2010; Milestone 2012). Peak treatment season lasts "a couple of weeks" and typically cutter and treater equipment operate 12 hours per day (Milestone 2012). This generally agrees with information from the National Potato Council (2011) that the typical day would be 10 to 12 hours per day for a grower and 12 to 16 hours for a commercial treater. The selected short-term throughput value is the "typical" hourly output of the largest dust or liquid treater (Model 42 – 1,000 cwt per hour) times 8 hours per workday. The selected intermediate-term throughput value is the "typical" hourly output of the mid-sized dust or liquid treater (Model 36 – 500 cwt per hour) times 8 hours per workday.
Rice	302,500	180,000	Treatment facilities for this crop were surveyed (AHETF 2013). Survey indicates that 64% of rice is treated in commercial facilities and 16% is treated downstream and the remaining 20% is not treated. The survey reports that commercial facilities operate 35 days per year (50th percentile; range 6 to 86 days).
Small Seeded Vegetables[6] **Film Coated**	3,000	3,000	General information from a small number of facilities (exact number not reported) which film-coat small seeded vegetables (AHETF 2010).
Small Seeded Vegetables[6] **Encrusted or Pelleted**	225	225	General information from three facilities that encrust or pelletize small seeded vegetables (AHETF 2010).

Table 2.1.1. Recommended Values for Amount of Seed Treated (AST) Per Day: Commercial and Downstream Seed Treatment Facilities.			
Surveyed Crops	Lbs of Seed Treated per 8-hr Work Shift[1]		Basis and Comments
	Short-Term[2]	Intermediate-Term[3]	
Soybeans	281,250	200,000	Treatment facilities for this crop were surveyed (AHETF 2013). Survey indicates that 5% of soybeans is treated in commercial facilities, 39% is treated downstream, 2% is treated by the grower, and 54% is not treated. The survey reports that commercial facilities operate 178 days per year (50th percentile; range 1 to 243 days). Note: Duration of downstream treatment is reported as 42 days (50th percentile; range 4 to 120 days).
Sunflower	80,000	38,500	Treatment facilities for this crop were surveyed (AHETF 2013). Survey indicates that 98% of sunflower seeds are treated in commercial facilities (remaining 2% is not treated). The survey reports that commercial facilities operate 173 days per year (50th percentile; range 65 to 251 days).
Wheat	360,000	180,000	Treatment facilities for this crop were surveyed (AHETF 2013). Survey indicates that 18% of wheat is treated in commercial facilities, 13% is treated downstream, 18% is treated by the grower and 51% is not treated. The survey reports that commercial facilities operate 35 days per year (50th percentile; range 1 to 82 days).

1. AHETF Survey (AHETF 2013) shows that work shifts can be longer than 8-hrs per day and that multiple shifts per day occur during the peak treatment season; however, values for an 8-hr day were chosen as representative of a typical work day. Note that the survey respondents self-determined the categories "typical", "normal", and "peak."
2. The short-term value selected is the 75th percentile of the typical throughput during the peak treatment period as reported in the AHETF survey (AHETF 2013).
3. The intermediate-term value selected is the 75th percentile of the typical throughput during the normal treatment period as reported in the AHETF survey (AHETF 2013).
4. Survey data are not available on the percent of the crop receiving seed treatments, where seed treatments occurs (i.e., commercial, downstream, on-farm), duration of the seasonal seed treating period, and daily throughput.
5. Cwt = hundred weight or 100 lbs.
6. Small and large seeded vegetables are listed in Appendix A.

Translation from AHETF Data

Due to the limitations of the AHETF data, crop-specific translations will be necessary to determine AST. **Table 2.1.2** provides examples of possible crop translations for a select number of crops. Additional translations are possible, but would need to be addressed on a case by case basis.

Table 2.1.2. Examples of Possible Crop Translations Based on AHETF Survey.	
Seed Type included in AHETF Survey	Translatable Crops
Canola (Rapeseed)	Flax, Lespedeza, Mint, Mustard Seed, Sesame
Corn (field)	Corn (sweet), Corn (pop)
Soybean	Beans, dry
Wheat	Barley, Japanese Millet, Oats, Pearl Millet, Proso Millet, Rye, Safflower, Sorghum, Triticale

2.2 On-Farm Seed Treatment

Currently, with the rapid turnover of seed varieties, farmers have chosen not to store high-value treated seed that can lose viability or become outmoded in one season, necessitating on-farm seed treatments prior to planting. For example, farmers may purchase seeds which are commercially treated with an insecticide and then custom treat the entire or partial amount of seed with a fungicide on-farm.

In North America, seeds can be treated with a variety of procedures shortly before being planted at the farm site. This is commonly referred to as "on-farm" seed treatment and can involve the application of liquid and/or solid products directly onto the seed. Applications can be made before the seed is put into planting equipment or directly on seed already loaded in planting equipment (i.e., in the seed hopper box).

Table 2.2.1 provides a guide for choosing standard values for the amount of seed treated per day for on-farm seed treatment. The values in this table were derived by using ExpoSAC Policy 9 "Standard Values for Daily Acres Treated in Agriculture" and maximum amount of seed planted per acre values provided in the BEAD memo "Acres Planted Per Day and Seeding Rates of Crops Grown in the United States" (J. Becker, March 2011). It should be noted that the list of crops included in this table is not exhaustive, and if a product label indicates on-farm seed treatment for a crop not listed, the assessor can estimate the pounds of seed treated per day for that crop. A value for acres planted per day can be chosen from ExpoSAC Policy 9, and a value for the maximum seeding rate can be chosen from the 2011 BEAD memo. These two values are multiplied in order to estimate the pounds of seed treated per day for on-farm treatment.

Table 2.2.1: Amount of Seed Treated (AST) Per Day for On-Farm Seed Treatment.			
Seed Type	Acres Planted per Day[1]	Maximum Seeding Rate (lbs of seed planted per acre)[2]	Pounds (lbs) of Seed Treated per Day for On-Farm Seed Treatment[3]
Barley	200	98	19,600
Corn (field)	200	30	5,910
Cotton	200	19	3,780
Flax	80	50	4,000
Oats	200	90	18,000
Peanuts	80	228	18,300

Table 2.2.1: Amount of Seed Treated (AST) Per Day for On-Farm Seed Treatment.			
Seed Type	Acres Planted per Day[1]	Maximum Seeding Rate (lbs of seed planted per acre)[2]	Pounds (lbs) of Seed Treated per Day for On-Farm Seed Treatment[3]
Potato	61	6,970	425,000
Rice	200	156	31,300
Rye	200	90	18,000
Safflower	80	35	2,800
Sorghum	80	12	960
Soybeans	200	167	33,300
Tomato	80	1.1	87
Triticale	200	109	21,800
Wheat	200	157	31,400

1. Acres planted per day represented by the values for acres sprayed per day from ExpoSAC Policy 9: "Standard Values for Daily Acres Treated in Agriculture". These assumptions may be further refined if crop-specific seed planting data are available. The acres planted for potato seed pieces has been refined from ExpoSAC policy 9 since specific information is available on the maximum number of acres that can be planted in an 8-hr day using a conventional 8-row potato planter (Table 2 from BEAD memo "Acres Planted Per Day and Seeding Rates of Crops Grown in the United States" (J. Becker, March 2011).
2. Seeding rates provided by BEAD memo "Acres Planted Per Day and Seeding Rates of Crops Grown in the United States" (J. Becker, March 2011).
   - Table 10 provides lb seed/A for barley, oats, rye and safflower. Table 9 provides lb seed/A for sorghum and triticale.
   - Corn seeding rate calculated from maximum seeds/A (Table 4, 40,250) and low end seed count (1,361 seeds/lb, Table B-1).
   - Cotton seeding rate calculated from maximum seeds/A (Table 6, 85,000) and low end seed count (4,500 seeds/lb, Table B-1).
   - Seeding rate for flax: https://www.ag.ndsu.edu/cpr/plant-science/flax-production-4-26-12.
   - Peanut seeding rate calculated from maximum seeds/A (Table 10, 105,000) and low end seed count (460 seed/lb, Table B-1).
   - Rice seeding rate calculated from maximum seed/A (Table 8, 2,438,360) and low end seed count (15,600 seed/lb, Table B-1).
   - Soybean seeding rate calculated from maximum seed/A (Table 5, 250,000) and low end seed count (1,500 seed/lb, Table B-1).
   - Tomato seeding rate calculated from maximum seed/A (Table 10, 130,680) and low end seed count (120,000 seed/lb, Table B-1).
   - Wheat seeding rate calculated from maximum seed/A (Table 7, 1,500,000) and low end seed count (9,550 seed/lb, Table B-1)
3. Derived from multiplying acres treated by maximum pounds of seed planted per acre.

3.0 Amount of Seed Planted (ASP)

Seed planting equipment has become more precise and sophisticated in recent years, which has allowed growers to better estimate the number of seeds needed for their specific planting rates, and better determine the cost of planting seeds in their fields. Determining the number of seeds planted per day (i.e., seeding rate) for a specific seed crop is dependent upon: (1) the desired number of plants per acre, which depends on the spatial arrangement (within-row or between row spacing) of the plants; (2) the number of seeds per pound (i.e., seed count); (3) the percent germination; (4) planting precision; and (5) hours worked per day.

Treated seeds are increasingly sold by count instead of weight. The number of seeds that weigh one pound is referred to as "seed count." The seed count is a function of the individual seed's weight and size (i.e., there is a smaller count of larger/heavier seeds in one pound than smaller/lighter seeds). Because seeds are not uniform in size or weight, even within the same

type of seed, and can vary depending on environmental factors (weather, soil, etc), storage conditions and heritable traits, farmers prefer to purchase seed by count rather than weight.

Therefore, the seed treatment industry is increasingly providing seed count information on the package and is selling seed by count rather than by weight or volume. The American Seed Trade Association (ASTA) filed a petition to amend Handbook 133 of the National Institute of Science and Technology (NIST) (which includes procedures for testing packages labeled by weight, volume, measure and count) to match the standards of the Association of Official Seed Analysts (AOSA) for testing seeds. The National Conference on Weight and Measures passed a vote to standardize testing methods and procedures for seed count labeling which became effective January 1, 2011. This amendment is specific to corn, soybean, field bean and wheat seed.

Different types of planters (including broadcast, drill, precision, or specialized) are classified based on the number of rows each planter is capable of planting. Different planters account for the variation in seeding and plant density. Some planters provide a broad placement of seeds that can reach up to three times the amount needed for a given acreage, whereas other planters provide precision planting seeding rates that provide the exact number of desired plants (assuming 100% germination).

The number of acres planted per day is dependent upon a number of variables such as planter size (number of rows), farm size, and hours worked. The number of hours a day spent planting seeds can vary depending on the length of the planting window, types of equipment used, and local conditions (i.e., weather).

Seeding rates are commonly expressed in some measure of volume per acre (e.g., bushels per acre) or in weight per acre (e.g., pounds per acre). Farmers estimate the proportion of seed that will actually germinate to determine the pounds of seed needed per acre. Depending on the crop, the seed germination rate can range anywhere from 70 to 90%. To compensate for less than 100% germination, farmers typically plant extra seed.

Table 3.1 provides a summary of the default values for the amount of seed planted per day for several crops.

Table 3.1. Amount of Seed Planted Per Day.

Crop	Number of Seeds/lb[a]	Seeds/A[a]	Seeding Rate (lbs seed/ acre)[a]	Acres Planted per Day[a]	Amount of Seed Planted per Day (lb)[a]
Alfalfa	227,000	3,405,000	15	200	3,000
Asparagus	15,682	156,816	10	80	800
Barley	9,400	921,200	98	200	19,600
Beans, dry	800	130,680	163	200	32,700
Bean, lima	907	95,040	105	200	21,000
Bean, navy	1,814	418,176	231	200	46,100
Bean, snap	1,814	418,176	231	80	18,400
Beets, garden	25,344	633,600	25	80	2,000
Beets, sugar	22,000	435,600	20	200	3,960
Broccoli	80,000	210,845	2.6	80	211
Brussels sprouts	64,000	27,878	0.44	80	35
Cabbage	45,000	98,010	2.2	80	174

Table 3.1. Amount of Seed Planted Per Day.					
Crop	Number of Seeds/lb[a]	Seeds/A[a]	Seeding Rate (lbs seed/ acre)[a]	Acres Planted per Day[a]	Amount of Seed Planted per Day (lb)[a]
Cabbage, Chinese	45,000	52,272	1.2	80	93
Canola	90,000	740,520	8	200	1,650
Cantaloupe	16,000	13,403	0.84	80	67
Carrot	175,000	2,090,880	12	80	956
Cauliflower	80,000	21,780	0.27	80	22
Celery	1,000,000	69,696	0.070	80	6
Chicory	375,000	2,250,000	6	80	480
Chive	91,200	364,800	4[b]	80	320
Collards	134,400	537,600	4	80	320
Corn, field	1,361	40,250	30	200	5,910
Corn, pop	1,361	30,000	22	200	4,410
Corn, sweet	1,800	59,739	33	80	2,660
Cotton	4,500	85,000	19	200	3,780
Cowpea / Southern pea	3,200	139,392	44	80	3,480
Cucumber	12,000	139,392	12	80	929
Eggplant	14,520	14,520	1.00[c]	80	80
Endive	13,068	52,272	4[d]	80	320
Flax	60,984	3,049,200	50[e]	80	4,000
Kale	100,000	576,000	6	80	461
Kohlrabi	100,000	58,080	0.6	80	47
Leek	160,000[f]	149,349	1	80	75
Lentil	7,467	522,720	70	80	5,600
Lespedeza	240,000	8,400,000	35	80	2,800
Lettuce, head	400,000	313,632	0.78	80	63
Lettuce, leaf	400,000	157,000	0.39	80	31
Millet, Japanese	155,000	3,875,000	25	80	2,000
Millet, pearl	85,000	1,700,000	20	80	1,600
Millet, proso	46,667	1,400,000	30	80	2,400
Mint (peppermint, spearmint)	6,670,464[g]	78,408	0.012	200	2
Muskmelon	16,000	38,848	2	80	194
Mustard	181,000	1,267,000	7	80	560
Oat	13,000	1,170,000	90	200	18,000
Okra	2,904	43,560	15[h]	80	1,200
Onion, dry bulb	100,000	400,000	4	80	320
Onion, green	100,000	2,500,000	25	80	2,000
Parsley	150,000	6,000,000	40	80	3,200
Parsnip	87,120	435,600	5[i]	80	400
Pea, garden	1,361	560,057	412	80	32,900
Peanut	460	105,000	228	80	18,300
Pepper	50,000	209,088	4	80	335
Potato	5	34,848	6,970	61[j]	425,000
Pumpkin	1,600	7,260	5	80	363
Radish	32,000	1,045,440	33	80	2,610
Rice	15,600	2,438,360	156	200	31,300
Rutabaga	150,000	300,000	2	80	160
Rye	18,000	1,620,000	90	200	18,000
Safflower	13,608	476,280	35	80	2,800
Sesame	26,400	316,800	12	80	960
Sorghum	8,333	100,000	12	80	960
Soybean	1,500	250,000	167	200	33,300
Spinach	40,000	1,000,000	25	80	2,000
Squash, summer	1,920	11,616	6	80	484
Squash, winter	1,920	7,260	4	80	303
Sunflower	2,000	8,000	4	80	320

Table 3.1. Amount of Seed Planted Per Day.					
Crop	Number of Seeds/lb[a]	Seeds/A[a]	Seeding Rate (lbs seed/ acre)[a]	Acres Planted per Day[a]	Amount of Seed Planted per Day (lb)[a]
Swiss Chard	25,600	204,800	18[k]	80	640
Tomato	120,000	130,680	1.1	80	87
Triticale	15,000	1,635,000	109	200	21,800
Turnip	167,000	1,045,440	6	80	501
Watermelon	4,800	43,560	9	80	726
Wheat	9,550	1,500,000	157	200	31,400

a. Sources and Calculations:
Number of seeds/lb: low-end seed count from Table B-1 from BEAD memo "Acres Planted Per Day and Seeding Rates of Crops Grown in the United States" (J. Becker, March 2011) or information identified from web search.
Seed/A: high-end seeding/planting rates (seeds/acre) from BEAD memo "Acres Planted Per Day and Seeding Rates of Crops Grown in the United States" (J. Becker, March 2011).
Seeding Rate (lb seed/A): Calculated from number of seeds/A ÷ seeds/lb or from BEAD memo "Acres Planted Per Day and Seeding Rates of Crops Grown in the United States" (J. Becker, March 2011) or information identified from web search.
Acres planted per Day: Acres planted per day represented by the values for acres sprayed per day from ExpoSAC Policy 9: "Standard Values for Daily Acres Treated in Agriculture". These assumptions may be further refined if crop-specific seed planting data are available.
Amount planted per day: lbs seeds/A * acres/day

b. http://edis.ifas.ufl.edu/pdffiles/CV/CV12800.pdf
c. http://edis.ifas.ufl.edu/pdffiles/cv/cv12400.pdf
d. http://ufdcimages.uflib.ufl.edu/IR/00/00/34/79/00001/CV12600.pdf
e. https://www.ag.ndsu.edu/cpr/plant-science/flax-production-4-26-12.
f. http://www.ufseeds.com/Leek-Growing-Info.html
g. https://www.groworganic.com/out-rpk-pv-org-mint-peppermint-1-oz.html
h. http://extension.uga.edu/publications/detail.cfm?number=C627
i. https://nevegetable.org/crops/carrot-and-parsnip
j. The acres planted for potato seed pieces has been refined from ExpoSAC policy 9 since specific information is available on the maximum number of acres that can be planted in an 8-hr day using a conventional 8-row potato planter (Table 2 from BEAD memo "Acres Planted Per Day and Seeding Rates of Crops Grown in the United States" (J. Becker, March 2011).
k. http://aggie-horticulture.tamu.edu/vegetable/files/2011/10/swisschard.pdf

4.0 Planting Transplants Grown from Treated Seed

Small-seeded vegetable seeds are direct seeded in the field or grown from transplants. Transplant production has recently replaced direct seeding due to (1) increasingly high cost of hybrid seeds, (2) early-to-market cost advantages, (3) short growing seasons or a desire to grow multiple crops per season, (4) crops that are difficult to establish, and/or (5) the fact that planting transplants uses less seed per acre. Tomato, lettuce, cabbage, broccoli, and Brussels sprouts are fairly easy to transplant. Celery, onion, pepper, eggplant, and cauliflower are moderately well adapted to transplanting. Cucurbits can be difficult to grow from transplants due to very slow root re-development. Root crops such as carrots, beets, radishes, and turnips tend to form undesirable side roots when grown from transplants; therefore, are not typically grown from transplants. Small seeded vegetable seeds that are used to produce transplants may be primed, film-coated, and/or pelletized to improve handling during mechanized planting in greenhouses and/or in nurseries. There are three types of mechanical planters for transplants: manual, semi-automatic, and fully automatic. The semi- and fully automatic transplanters have replaced the manual transplanters for most commercial growers. Handler exposure from transplanting after treated seeds have been planted is highly unlikely due to the systemic nature of seed treatments. Thus, exposure during crop transplanting is not represented by the seed treatment scenarios covered in this policy (i.e., this policy is related to direct seeding scenarios). Exposure to pesticides while transplanting is better addressed in ExpoSAC Policy 3.

Glossary

Seed enhancement technologies
Seed enhancement technologies have enabled the vegetable industry to provide uniform crops at reduced seed cost per acre. Enhancements improve plantability (equal distance between planting resulting in nicely shaped vegetables) and reduces the amount of pesticide per acre compared to in furrow or other soil applications.

Priming
Seed priming is a hydration treatment in which dormant seed species are primed with aerated water under controlled environmental conditions to break dormancy and ensure fast and uniform germination when planted. Priming solutions can be supplemented with plant hormones or beneficial microorganisms. Seed priming can result in rapid, uniform and complete seedling emergence after planting; however, primed seed has a limited storage life compared to non-primed seed.

Encrusting
Encrusting increases seed weight from 50 to 200% without a significant change in seed shape. Encrusted seed may appear similar to film-coated seed (but adds more weight to seed) and is sometimes referred to as mini-pelleting (less weight than pelleting) or coating. Seeds are encrusted to fill in holes and indentations of seed (primarily carrots and onions). Onions are commonly encrusted. Encrusted seed has a small quantity of material added to it to minimally change the shape of the raw seed to enable accurate mechanical seed metering in greenhouse and field applications.

Film-Coating
Film coating puts a very thin colored film around the seed increasing the weight of the seed by about 5%, without changing the original size or shape of the seed. The film coat is generally made up of a water permeable polymer, a plasticizer and a colorant. Three basic reasons to film coat seeds are 1.) maintains pesticide on the seed for maximum affect (completely enclosed around seed) and reduces pesticide exposure to handlers; 2.) helps seed flow better in the planter box and/or metering during loading and planting; and 3.) colorant makes seed easier to pick out of the soil when checking for seed spacing during planting.

Film coating of small seeded vegetable seeds in the U.S. are typically accomplished using rotary film coating systems (e.g., Rotostats™) and drum coaters such as side vented pan coaters. The seed is placed in a rotating drum and the film-coating material plus plant protection product (if desired) is sprayed directly onto the seed. The coated seed is then removed from the drum, dried and packaged ready for sowing. Although the treating time per batch is fairly short, the drying step can require several hours and is often the rate limiting step in treatment of small seeded vegetables.

Pelletizing
Pelletizing turns a seed light in weight and oddly shaped into a pellet which is heavier, more uniform, perfectly round a possible enabling planter to plant seed/pellet in the most precise mechanical way possible (precisely planting seed with desired amount of space between each

seed) resulting in nicely shaped product. Formation of pellet involves powders and adhesives applied around the seed to form a more or less spherical shaped dispersal unit. The original size, shape and weight are changed significantly, generally to a size and weight for a particular planting scheme. The increased weight can be from 1000 to 4000% (10:1 to 40:1 ratio). Depending on seed type and process, the weight of a pelletized seed can increase from 5-100 times the original seed weight. For example, commercial lettuce seed has a raw (commercial) seed count of 240,000-480,000 seeds per pound while pelleted lettuce seed count varies from 11,500 – 35,000 seeds per pound , a 20X to 13X decrease in seed count.

During the pelleting process raw seed is placed in a rotating drum also referred to as a pan treater or coating pan. The raw seed is misted with water or other liquids and gradually blended with fine inert powdered materials. Synthetic plant protection products can be added in either a dry or liquid form at almost any point during the pelleting process. Each seed becomes the center of an agglomeration of powder that gradually increases in size. The tumbling action serves to round and smooth the pellets. Binders and polymers are often added near the end of the pelleting process to harden the outer layer of the pellet and minimize dust-off for the finished product. At intervals during the pelleting process, the pellets are removed and mechanically sized on a set of vibrating screens. Smaller pellets are then returned to the coating pan for additional build up. The traditional side vent coating pans used for pelleting small seeded vegetable seeds are single batch open seed treatment systems; either standard flat pans or round pans with open sides. Regardless of whether the seed is pelleted in a Small Seeded Vegetables – rotary coater or the more traditional coating pan, the amount of time required to dry the seeds (2-4 hours) remains unchanged and hence drying is often the rate limiting step in treatment of small seeded vegetable seeds.

Breeder/producers
Companies that breed and produce small vegetable seeds in-house as much as possible including priming, film-coating, encrusting and pelleting. These companies will, however, contract with a seed treatment technology provider for a specific type of pellet or process which they have not developed internally due to complexity of process, or for which their volume is low enough for a specific process that it does not warrant developing an internal process. The only major exception to this rule is the lettuce market. In the lettuce market there are a number of local small breeder/producers which send all of the seed that they produce to one of the major technology provider companies for priming, film-coating, encrusting and/or pelleting to meet specific grower production practices.

Technology providers
Companies which concentrate on the development of seed treatment technology (i.e., prime, film-coat, encrust and/or pellet seed) to meet specific grower production practices. The major crops treated by the technology provider companies are leafy vegetables (primarily lettuce) and onion seeds but tomatoes, peppers and a limited amount of other species are also treated. Note that the technology providers also treat a significant amount of small seeded flower seeds (begonias, petunias, etc).

***Types of Planters*:**
- Broadcast planters randomly distribute seeds on the soil surface and a separate operation

is required to cover the seed (e.g., harrowing). Broadcast planters are often used to establish crops that have very small seeds (e.g., alfalfa) or those that require light to germinate (e.g., some pasture grasses).

- Seed drills are tractor-pulled that have a series of small plows or disks that open furrows in the soil and randomly drop seed into closely spaced furrows. This type of planter uses mass flow seed metering and is used to establish crops where there is little incentive to place seeds equidistant in the row. Almost all small cereal grains (e.g., oats, barley, wheat) are planted using drill planters.

- Precision planters are used to accurately place single seeds or groups of seeds equidistant in the row. This type of planter can use one of several types of precision metering devices (e.g., belts, plates) and is used to plant crops that require accurate control of the plant population. Crops planted with this type of planter include almost all horticultural crops (e.g., vegetables) and field crops (e.g., sorghum, corn, soybean, sunflower, and cotton).

- Specialized planters are considered here to be those that plant whole plants (e.g., seedlings or transplants), plant stems (e.g., sugar cane) or tubers and bulbs (e.g., potatoes and onions).

Appendix A. Small and Large Seeded Vegetable Assignments for Seed Treatment

Small Seeded Vegetables	
Asparagus	Kohlrabi
Beets, garden	Leek
Beets, sugar	Lentil
Broccoli	Lettuce, head
Brussels sprouts	Lettuce, leaf
Cabbage	Muskmelon
Cabbage, Chinese	Mustard
Cantaloupe	Okra
Carrot	Onion, dry bulb
Cauliflower	Onion, green
Celery	Parsley
Chicory	Parsnip
Chive	Pepper
Collards	Radish
Cucumber	Rutabaga
Eggplant	Swiss Chard
Endive	Tomato
Kale	Turnip
Large Seeded Vegetables	
Bean, lima	Pumpkin
Bean, navy	Squash, summer
Bean, snap	Squash, winter
Cowpea / Southern pea	Watermelon
Pea, garden	

Attachment 1: Documentation of Revisions

Date	Documentation of Revisions
March 2004	• Original version
December 2017	• Updated amount of seed treated commercially based on AHETF submissions • Updated amount of seed treated on-farm and amount of seed planted using 2011 BEAD memo which provided updated seeding rates
June 2021	• Removed reference to long-term seed treatment exposure duration and provided justification for excluding this duration from risk assessments • Fixed typographical error: review barcode reference of seed treatment survey review
January 2022	• Removed small and large seeded vegetable designations from Table 3.1. Moved designations to separate table in Appendix A for reference. • Changed footnotes to Table 2.1.1 to point to Appendix list for small and large seeded vegetables rather than listing out examples. • Removed Lespedeza designation as small seeded vegetable; added it to Table 2.1.2 as translatable from canola • Removed Proso millet designation as small seeded vegetable; added it to Table 2.1.2 as translatable from wheat • Removed Japanese millet designation as small seeded vegetable; added it to Table 2.1.2 as translatable from wheat • Removed Pearl millet designation as small seeded vegetable; added it to Table 2.1.2 as translatable from wheat • Removed mint designation as small seeded vegetable; added it to Table 2.1.2 as translatable from canola • Fixed typographical error in Table 3.1 for asparagus: seeds/lb changed from 15,862 to 15,682 • Deleted footnote "L" from Table 3.1 – reference not applicable • Updated swiss chard values for seeds/lb and seeds/A in Table 3.1 to better match with information from referenced footnote. • Edited Section 4.0 to clarify that exposure during crop transplanting is not represented by the seed treatment scenarios in this policy; transplanting is addressed in ExpoSAC Policy 3.