

Pesticide Use on Cannabis

Cannabis Safety Institute
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1. Abstract

Legalized cannabis production is a rapidly growing agricultural industry. However, given that cannabis production has developed and operated in an unregulated setting various practices have been adopted that are at odds with accepted regulations regarding human safety and environmental impacts. Chief amongst these is the unregulated use of pesticides, which has potentially serious public health and environmental consequences. In the absence of guidance from the Environmental Protection Agency on this subject, it is critical that state regulators enact programs to protect workers, the environment, and Cannabis consumers.

This paper presents data indicating that pesticide use is widespread in the Cannabis industry, and that pesticide residue on retail Cannabis products is often found at levels exceeding the allowable levels on any agricultural product. In addition, a set of basic recommendations is presented that will allow states to move forward safely until more detailed Cannabis-specific pesticide data is available.

2. Introduction

Pesticide use on Cannabis is an emerging public health threat. Cannabis is a high-value crop that is frequently damaged by molds and insects^{1,2}, and the recent surge in sales of immature clones has spread plant diseases widely across several states. Pesticide use has been increasing rapidly in response. Most research on pesticide toxicity is based on oral ingestion exposure, and this is the data used for determining acceptable residual tolerance levels on crops. Inhalation exposure through smoking presents a different set of risks. Smoking can create pyrolysis compounds with unknown toxicities, and inhaled chemicals enter the bloodstream without first undergoing first-pass metabolism by the digestive and hepatic systems. As a result, inhaled chemicals are typically present at much higher levels in the body than those that are orally ingested. Research has shown that pesticides on Cannabis can be transferred into Cannabis smoke with efficiencies as high as 70%³.

The data presented in this paper indicate that pesticides can now be found on close to half of the Cannabis sold in Oregon dispensaries. The potential dangers of this situation are magnified by the increase in popularity of Cannabis extracts. These are made by processes that appear to concentrate pesticides, leading to extremely high levels in the final product. Cannabis extracts are often smoked directly and most edible Cannabis products are made by adding these extracts into foods.

This issue is so far the most stark example of a situation which states have faced as they seek to implement legal Cannabis programs—which is that the absence of federal approval is often less problematic than the complete absence of federal guidance. The Environmental Protection Agency (EPA), in a complex and data-driven process, sets tolerances and regulates pesticide sale and usage. Approvals and tolerance limits are established by the EPA in a manner that is specific to each crop, to each type of application site, and to each pesticide compound. It is technically illegal to apply pesticides to any crop for which they are not specifically approved (see US code 7 U.S.C 136j). More troubling, in this case, is that safety data is not available for any pesticides on Cannabis. This puts Cannabis growers in a

difficult position, as many of them are now dependent to some degree on chemical pest management techniques. Cannabis growers are using a wide range of federally registered pesticides, yet they lack the guidance that other agricultural industries normally receive from the EPA, the USDA, and from land-grant universities that do agricultural extension work⁴. In response to requests from Colorado and Washington the EPA did recently release a letter indicating that they would accept applications for Special Local Need (SLN) registrations for pesticides intended for use on Cannabis. This is an extraordinary step, as it represents the first real acknowledgment of the Cannabis industry by a federal agency that normally regulates traditional agriculture. Nonetheless, SLN applications (though not as difficult and time-consuming as normal pesticide registrations) are still quite arduous and restricting, and at present it is unlikely that any company or state government will be willing to invest in the necessary application process.

This issue also puts independent Cannabis testing labs (ITLs) in a difficult position. In some states they have been instructed to test for pesticides, but have not been given clear guidance as to how to do so or what to test for. Regulatory agencies in multiple states are now attempting to determine guidelines for pesticide use on Cannabis, but doing so will require not only guidance for growers as to what compounds or methods are acceptable, but also guidance for growers and ITLs as to what compounds are unacceptable, and therefore must be tested for.

This paper is a comprehensive survey of pesticide use on Cannabis, compiled from data collected by Oregon Growers Analytical laboratory, in Eugene OR. The data is alarming, both because of the range of pesticides that were detected and because of the high levels that were found. It also provides strong evidence that the production of Cannabis extracts leads to the concentration of pesticides in the final product. Given the current lack of data regarding pesticide occurrence on Cannabis we hope the data presented here can serve as a foundation for the development of guidelines for pesticide use on Cannabis.

The Cannabis Safety Institute, in conjunction with a number of agricultural pesticide experts in several states, has assembled a set of recommendations that we believe will allow states to address this issue effectively until the federal government is willing to bring the full resources of the EPA to bear. These recommendations necessarily involve compromises that are unavoidable until we have higher quality data regarding the toxicity, behavior, and chemistry of each relevant compound in both Cannabis flowers and concentrates. Nonetheless, they provide a set of guidelines that will protect public health, and allow growers, ITLs, and state regulators to move forward. These recommendations are outlined in the final section of this document.

3. Regulatory structure for the enforcement of pesticide regulations

Most states have existing programs for the regulation of pesticide usage on agricultural crops. One of the goals of this document is to explore how such programs can be adapted to the production of Cannabis and to identify those challenges that are unique to this commodity. A working regulatory system for agricultural pesticides requires interactions between producers, government, and ITLs. The critical components of this structure are

depicted in Fig. 1. The government (in this case, the state government alone) plays a central role in this system in that it must establish the overall rules and implement a program for inspection and enforcement. With regards to growers, the governing body must (1) establish licensing requirements, (2) provide of a list of allowed pesticides, and (3) set up a system for on-site inspections. Growers must be required to obtain appropriate licenses for the application of pesticides and must report pesticide usage to the governing agency.

With regards to ITLs, the government must (1) establish licensing requirements, which should include the requirement that the ITL is accredited to an appropriate standard set forth by the government, (2) establish a minimal list of pesticides that the ITL is required to include in analytical screens, (3) establish maximum residue limits for pesticides that may be found, and (4) set up a system for on-site laboratory inspections. In turn ITLs must be required to maintain appropriate accreditation and report their accreditation status to the governing body. In addition a system must be established to allow ITLs to report samples that are in violation so appropriate actions can be taken.

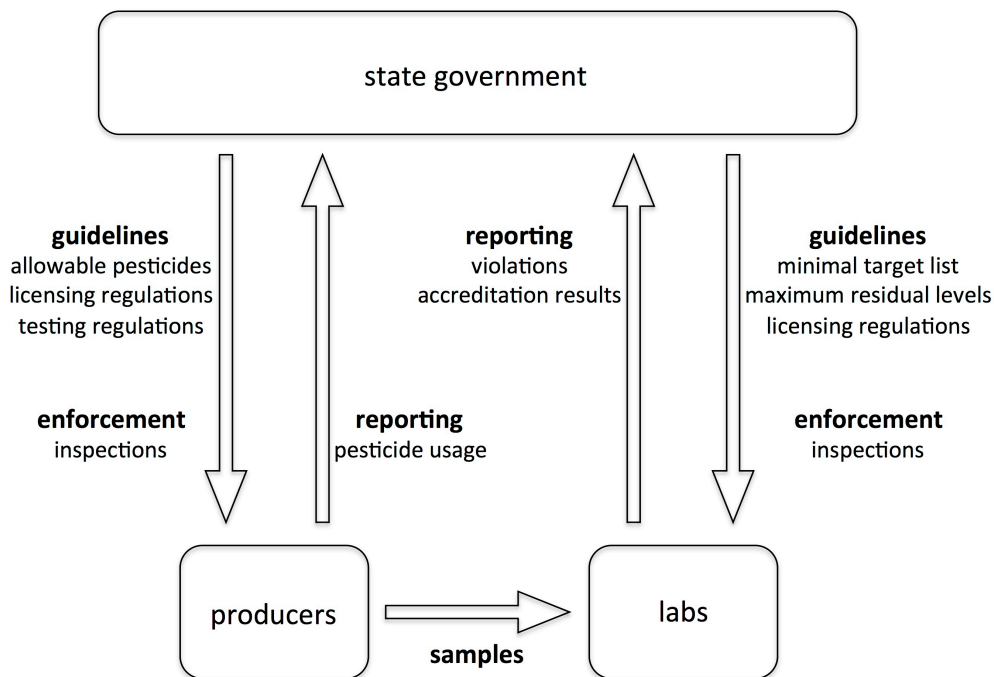


Figure 1. Regulatory structure for pesticide use on agricultural products.

4. Pesticide residues on medical Cannabis in Oregon.

Because of state-to-state differences in Cannabis regulations each state is facing unique challenges in implementing effective programs for managing pesticide usage on Cannabis. The data presented below was collected in Oregon, and it is best understood in the context of the current Cannabis testing landscape in that state. Although some of the issues discussed are unique to Oregon, many are likely to be shared by other states. All of them provide important context for the difficulties of instituting pesticide regulations for a new agricultural crop in the absence of federal involvement.

4a. Current Cannabis testing landscape in Oregon.

In Feb. 2014 Oregon adopted rules (OAR 333-008) governing the sale of medical marijuana in Oregon. Included in these rules was the requirement that marijuana and marijuana products must be tested to ensure that they are free of pesticide contamination. These rules have several serious flaws that in effect lead to a false sense of assurance regarding the actual safety of Cannabis products sold within the state. However, the ways that these rules backfired is instructive, and make it relatively clear how they should be written in the future.

OAR 333-008-1190 states that marijuana must be tested for “*pesticides by testing for the following analytes: (i) chlorinated hydrocarbons, (ii) organophosphates, (iii) carbamates, and (iv) pyrethroids.*” And that a “*sample of usable marijuana shall be deemed to test positive for pesticides with a detection of more than 0.1 parts per million of any pesticide*”. In other words, four classes of pesticides must be tested for, and samples failed if they have levels above a given cutoff (0.1ppm). These four classes of pesticides are actually composed of hundreds of compounds (according to the PAN database -- www.pesticideinfo.org -- 491 individual compounds fall into these categories). Pesticide screening involves identifying individual compounds, not classes of compounds. Thus, in order to actually meet the rule each sample would have to be screened for 491 individual compounds. This is quite simply impossible and would cost an inordinate amount of money to attempt.

In addition, many of the pesticides that are actually being used on Cannabis do not fall into these arbitrarily chosen classes. The specified categories include many potentially dangerous chemical insecticides, but they exclude many others. In addition, they do not include fungicides or plant growth regulators (PGRs), both of which are commonly used on Cannabis. The state-specified categories carry the quite dangerous implication for growers that other types of compounds are, by definition, acceptable. It is, in effect, a list of compounds that includes many that are irrelevant (for instance haven't been available in the US for decades), many that cannot be screened for, and fails to include many others that are actually being used.

This Oregon state law was passed with good intentions, and at the time it was one of the few laws anywhere that required pesticide testing on medical marijuana. Nonetheless, it is an excellent example of the dangers of enacting science-based legislation without adequate oversight by scientists. The law did not specify a list of allowable pesticides, or a meaningful list of disallowed pesticides. It put ITLs in the position of choosing arbitrary lists of compounds to screen for, because the full list was impossible, and it put them in the position of having to pass samples that were clearly contaminated by dangerous compounds that were not in the classes specified by law.

This law put no regulatory structure or enforcement protocols in place, and did not require that laboratories meet any standard of accreditation whatsoever. It therefore led to a vigorously expanding testing industry in which most labs were using inappropriate techniques to screen for arbitrarily chosen lists of compounds using unvalidated protocols.

Growers had no guidance as to what they could use, ITLs had no guidance on what to test for, and consumers were given products with labels that implied they were “pesticide-free”. These labels were generally misleading, as the data below illustrates.

4b. Study outline.

Despite the shortcomings of the current regulatory system, OAR 333-008 forced ITLs to develop pesticide-screening methods for Cannabis. Amongst these was Oregon Growers Analytical (OGA), which is a Cannabis-testing laboratory, located in Eugene OR and for which one of the authors (Rodger Voelker) is lab director.

Between March and July of 2014 OGA worked on developing and validating methods suitable for the determination of pesticide residues on Cannabis and Cannabis extracts. The method that was adopted is based upon the universally accepted AOAC 2007.01 multi-residue method (generally known as QuEChERS) with specific adaptations for Cannabis and Cannabis extracts. The primary technical challenge associated with the use of the QuEChERS method for Cannabis is the high level of Cannabis related compounds during the initial extraction. These co-extractives are largely composed of terpenes, cannabinoids, and various alkanes. OGA therefore developed a solid-phase extraction (SPE) cleanup step to remove as many of these compounds as possible. After cleanup the extracts are analyzed using a combination of GC-MS (using an Agilent 6890 GC coupled to an Agilent 5973 single-quad MS) and LC-MS/MS (using an Agilent 1100 HPLC coupled to an AB Sciex API3200 triple-quad MS/MS). Method detection limits (MDLs) range from 10 – 1000 ppb depending upon the analyte.

The data presented is from 389 samples of Cannabis flowers and 154 samples of concentrates, analyzed between October and December of 2014. A list of 65 compounds was tested for. This list was developed based on USGS pesticide use data, extensive conversations with growers, and a set of sales data provided to the Cannabis Safety Institute by two major grow-supply shops that service the industry. We believe this list provides good coverage of the pesticides likely to be in use in the Cannabis industry. Of the 65 compounds that were screened for, the 24 shown in Table I were detected on Cannabis flowers or extracts. With further method development, and an expanded list of analytes, it is likely we would find further compounds that we did not discover in this study.

Organophosphates	Organochlorines	Other
Chlorpyrifos	4,4'-DDE	Abamectin
Coumaphos	cis-Chlordane	Azadirachtin
Diazinon	trans-Chlordane	Bifenazate
Dichlorvos		Imidacloprid
Ethoprophos	Pyrethroid	Myclobutanil
Malathion	Bifenthrin	Paclobotrazol
Mevinphos	Cypermethrin	Piperonyl Butoxide
	Permethrin	Metalaxyl
N-methyl Carbamates		Chlorfenapyr
Carbaryl		
Propoxur		

Table 1: Pesticides detected on Cannabis products in this study.

4c. Frequency of pesticide detection.

A large proportion of samples in this study tested positive for pesticides. If this were a different agricultural crop, that alone would not necessarily be cause for concern. The EPA establishes specific tolerances for each pesticide on each crop. However, many of these Cannabis samples would also fail typical EPA guidelines for agricultural products. Figure 2A shows the distribution of samples that tested positive (*ie*, above the method detection limit) for one or more of the pesticides listed in Table 1. Figure 2B shows the distribution of samples that exceeded Oregon tolerances as defined in OAR 333-008 (see section 4a) for one or more of the organophosphate, organochlorine, N-methylcarbamate, or pyrethroids listed in Table 1. Figure 2C shows the distribution of samples that contained any of the compounds listed in Table 1 at levels that would reasonably be considered to violate EPA rules. Since the EPA has not registered any pesticides for use on Cannabis, technically any application of a pesticide to Cannabis is a violation of EPA rules. For the purposes of this analysis, we consider samples to be in violation of EPA guidelines if they have greater than 100 ppb of any pesticide in Table 1 with the exception of azadirachtin and piperonyl butoxide (PBO). Azadirachtin is a naturally occurring compound found in Neem seeds, has low toxicity and according to 40CFR 180.905 is exempt from EPA tolerances. Detections of

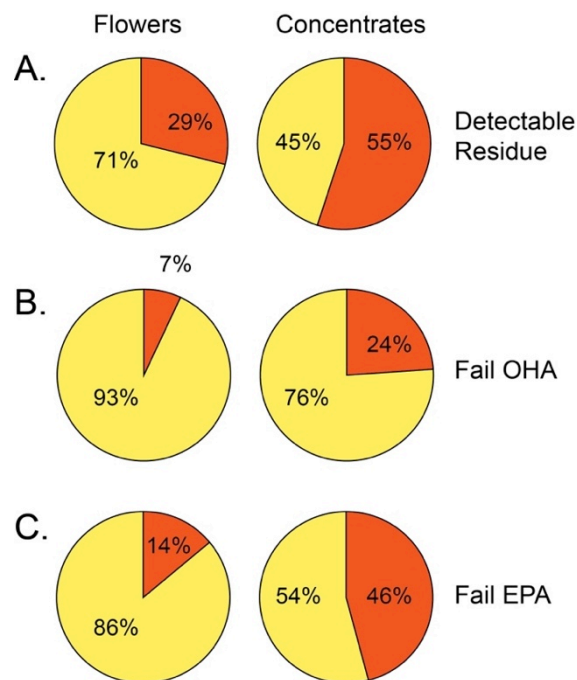


Figure 2: (A) Proportion of samples that tested positive for any detectable level of pesticide residue. (B) Proportion of samples having greater than 100 ppb of one or more pesticides covered by the current OHA rules. (C) Proportion of samples having greater than 100 ppb of any pesticide in Table 1 with qualifications as described in the text.

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azadirachtin were therefore omitted from this analysis. PBO is a synergist that is frequently added to pesticides to increase their effectiveness. PBO is not itself a pesticide, but it has been given an EPA tolerance of 8000 ppb for fruits and vegetables. For the sake of this analysis detection of >10,000 ppb of PBO was deemed a failure. Using these guidelines, 14% of the flowers would fail and nearly half of the concentrates would fail.

After PBO, the next most commonly detected pesticides were bifenazate and myclobutanil. These are not currently covered by OHA tolerances but are found in nearly 10% of all samples. The most commonly found compounds that are currently covered by the OHA rules are bifenthrin (found in 7% of samples) and malathion (found in 3% of samples).

4d. Levels of pesticides detected.

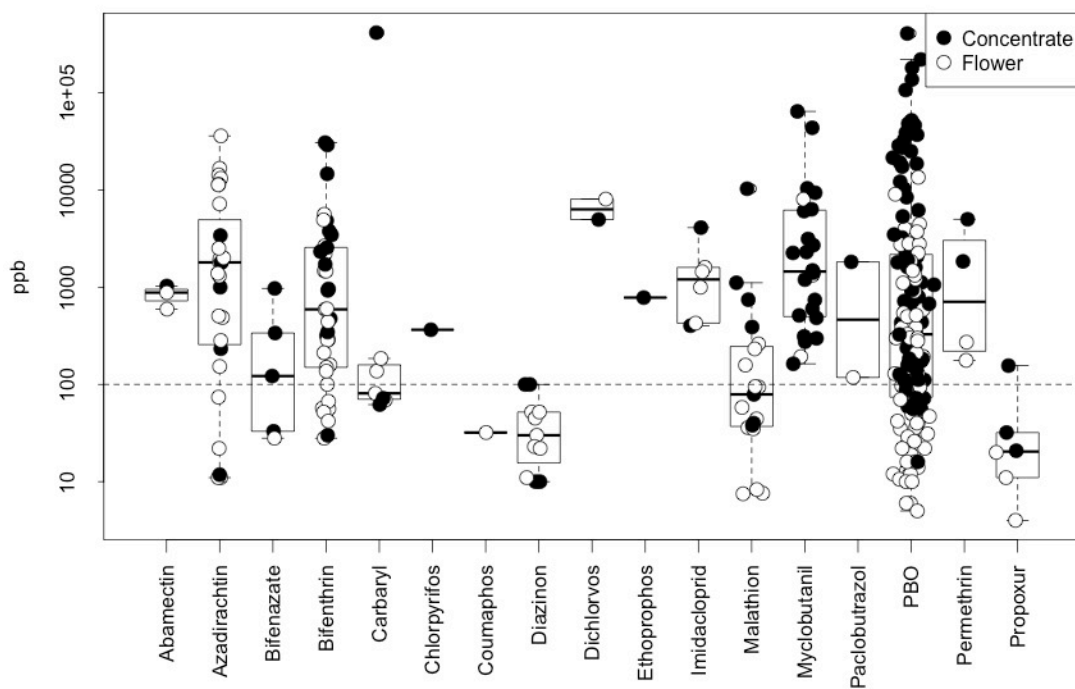


Figure 3. Distribution of observed levels as a function of compound and product type. Shown are boxplots for each compound indicating the mean (solid black line) and quartiles. Overlaid on each boxplot are individual data points colored by product type (see legend). 100 ppb is indicated as a hashed line. Note: the y axis is log scaled so each increment represents a 10x level than the previous increment.

The EPA sets strict guidelines for allowable levels of pesticides on raw commodities sold within the US. These are set individually for each combination of product and pesticide, but values typically range from 10 ppb to 10,000 ppb. The levels of the most commonly found pesticides on Cannabis and Cannabis products are shown in Figure 4. Note that the Y-axis is

logarithmically scaled to accommodate the wide range of observed levels. The mean levels for most pesticides are between 1000 – 5000 ppb. More significantly, however, 12% of samples have levels that exceed 10,000 ppb, and 1.9% of samples have levels even greater than 100,000 ppm.

4e. Concentration of pesticides in Cannabis extracts.

Further inspection of the data indicate that the mean levels of pesticides in concentrates is higher than that found in flowers. The high levels of pesticide residue in concentrates is consistent with the hypothesis that processes used to concentrate cannabinoids (*ie.* butane, pentane, CO₂ extraction) also concentrate pesticides. This phenomenon is more clearly demonstrated in Figure 4 which shows the distributions of PBO and bifenthrin levels observed for flowers versus concentrates. In both cases the mean level observed on concentrates is roughly 10x higher than the mean for Cannabis flowers.

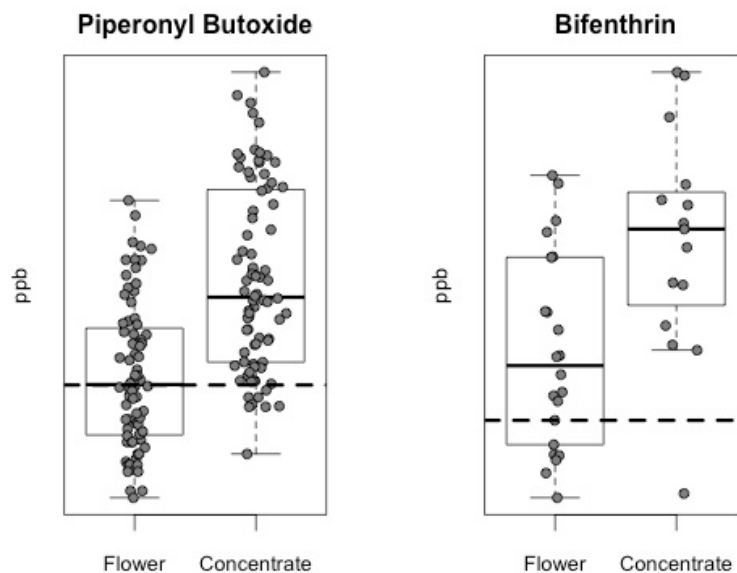


Figure 4. Distributions of the levels of PBO and bifenthrin for flowers versus concentrates. The OHA limit of 100 ppb is shown with a black hashed line. Note: The Y-axis is log scaled.

It is not surprising that cannabinoid extraction techniques also extract and concentrate pesticides. This is consistent with the fact that many pesticides have chemical properties (*e.g.* polarity and solubility) that are similar to cannabinoids. However, the observation that the mean level of pesticides appears to be roughly 10x higher in concentrates versus flowers is somewhat surprising, given that cannabinoids are only about 2-5x more concentrated in extracted products. Several factors could be contributing to this phenomenon, including (1) that some pesticides are more efficiently concentrated by these extraction techniques than cannabinoids are, (2) that chronic contamination of equipment and solvents may lead to cross contamination of later products, and/or (3) because it is a common practice to make concentrates from 'trim' which is left over after harvesting the

quality buds and the ‘trim’ may be more heavily contaminated than the buds which are sold and analyzed separately.

4f. Discussion

Since the EPA has not established tolerances for pesticides in Cannabis it is difficult to determine how many samples should be considered to have levels that are excessive. However, pesticide tolerances generally range from 10 – 10,000 ppb for other commodities. Using this standard it is clear that a significant proportion of Cannabis products contain problematic levels of pesticides, and the observation that nearly 5% of concentrates have pesticide contamination at levels that exceed 50,000 ppb is particularly disturbing. Even more alarming is the discovery that some concentrates contain compounds such as PBO, carbaryl, myclobutanil, and chlorfenapyr at levels greater than 100,000 ppb (figure 4 and table 2). These levels grossly exceed tolerances for pesticides on any commodity, and it is important to note that chlorfenapyr is not registered for use on any food commodities.

Table 2 is a list of individual samples with the highest levels of pesticides observed so far. These results clearly demonstrate that many products, especially concentrates, have levels of pesticides that greatly exceed EPA tolerances for these compounds on any commodities. It can also be clearly seen that the highest levels of pesticides observed in concentrates greatly exceeds the highest levels found on Cannabis flowers.

Flowers				Concentrates			
ID	Matrix	Pesticide	Conc (ppb)	ID	Matrix	Pesticide	Conc (ppb)
76	Flower	Imidacloprid	64,000	*52	BHO	Carbaryl	415,000
***33	Flower	Azadirachtin	36,000	**12	BHO	PBO	407,000
**94	Flower	PBO	22,700	**19	CO2	Myclobutanil	392,000
***34	Flower	Azadirachtin	16,700	**69	BHO	PBO	220,000
64	Flower	Imidacloprid	15,300	*83	BHO	PBO	180,000
***37	Flower	Azadirachtin	14,274	**06	BHO	Myclobutanil	160,000
***98	Flower	PBO	13,500	**67	BHO	PBO	137,000
***39	Flower	Azadirachtin	13,200	**20	RSO	Azadirachtin	123,000
***38	Flower	Azadirachtin	11,450	**81	CO2	Myclobutanil	110,000
***35	Flower	Azadirachtin	11,300	***32	BHO	PBO	106,700
***69	Flower	PBO	9,040	**19	CO2	Chlorfenapyr	100,000
***09	Flower	Dichlorvos	8,058	***34	BHO	Myclobutanil	64,310
***84	Flower	Myclobutanil	8,039	**29	CO2	PBO	52,000
***36	Flower	Azadirachtin	7,200	***34	BHO	PBO	48,160
***17	Flower	Bifenthrin	5,621	***56	BHO	PBO	46,440
***18	Flower	Bifenthrin	4,925	**24	CO2	PBO	44,500
96	Flower	PBO	4,450	*50	BHO	Myclobutanil	43,600

Table 2: Specific examples of samples with high levels of pesticide residues. Note: Sample IDs have been masked.

In addition to chlorfenapyr this study revealed the use of other products that are not registered for use on consumed commodities. Discussions with growers revealed that plant growth regulators (PGRs) are sometimes used on Cannabis. We therefore included

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paclobutrazol, which is a PGR that is not registered for use on food crops. Consistent with the anecdotal information, we have so far identified 9 samples having paclobutrazol contamination.

The most commonly observed contaminant is PBO. PBO is not itself a pesticide but is a synergist that is often mixed with products containing pyrethroids and carbamates to increase their toxicity. It is generally considered to be relatively non-toxic, in comparison to other pesticides, but it is listed as potentially carcinogenic by the EPA, and it is potentially hazardous to multiple species in the environment. PBO is regulated by the EPA as a pesticide and strict tolerances have been established. PBO is an ingredient in over 1600 registered pest control products, and it is likely that the frequent contamination and excessive levels of this compound on Cannabis indicate widespread and excessive usage of pesticides that this screen is not detecting. Many of these are likely to be natural pyrethrins, which are given a broad exemption by the EPA and are difficult to detect and quantify in Cannabis extracts. Nevertheless, even natural pyrethrins are considered low-toxicity only in the absence of PBO, and many other pesticides are also frequently combined with PBO. The nearly ubiquitous contamination of Cannabis products with PBO is consistent with excessive usage of pesticides on Cannabis, suggesting the need for education of growers to help reduce their reliance upon pesticides.

During the course of this study we identified several practices that do not involve direct application of pesticides to Cannabis crops but nonetheless result in pesticide contamination. The most frequently detected compound that falls within the current OMMP rules and causes the most failures due to excessive levels is bifenthrin. Bifenthrin is a synthetic pyrethroid that is commonly used in the Cannabis industry in the form of a total release aerosol that is used to 'bomb' grow-rooms in between crops to control spider mites. We discovered that this is not only a common practice but it is widely believed that, because the plants were not present during the application, there would not be consequential contamination of the next Cannabis crop. However, in working with growers we have discovered that bifenthrin applications lead to long term contamination of work spaces, tools, lights, and ventilation systems that results in chronic cross-contamination of later crops. Another interesting source of indirect contamination involves dichlorvos, which is an organophosphate. Dichlorvos is an active ingredient in certain pest-strips, which, despite being labeled as inappropriate for use in food production facilities, is commonly used to help control mites in in-door grows. However, we have identified at least five instances where Cannabis flowers have tested positive for dichlorvos and in each case the grower revealed that they were using pest-strips that contained dichlorvos.

5. Recommendations

Under the current US regulatory system pesticides must be registered with the EPA. The EPA sets tolerances for pesticide residues that may remain on crops sold within the US and requires that all pesticide products be labeled to indicate approved usage. Unfortunately Cannabis is not considered a crop and does not fall into any category for which the EPA (or the FDA or USDA) have oversight. The only guidance that states currently have is in reference to FIFRA (see US code 7 USC 136j-a2g), which states that it is unlawful to use a pesticide in a manner that is inconsistent with its label. Therefore, since no pesticides are labeled for usage on Cannabis, any application of a registered pesticide is in violation of FIFRA.

This situation leaves little room for states to maneuver as they develop policies regarding usage of pesticides on commercial Cannabis and attempt to remain in compliance with FIFRA. The irony of the situation is not lost on us – it seems odd to be concerned about breaking one particular federal law in the course of explicitly violating a different one. Nonetheless, we don't believe that regulators in any state, having thought carefully about this issue, will choose to be in noncompliance with FIFRA. The federal government has signaled some degree of willingness to tolerate state-level programs that violate the Controlled Substances Act and DEA regulations regarding Cannabis. Extending this to violations of other parts of the federal code is an invitation to federal intervention that would likely not limit itself to the matter at hand. State efforts to protect public health in the course of experiments with legal Cannabis must be extremely vigorous if these programs are to be allowed to continue.

The only way that states can comply with FIFRA in these respects is to approve only compounds that are exempt from tolerance limits under 40 CFR 152, and that – in addition – are labeled for broad usage such that their application to Cannabis is not in violation of the product label. Several states including Washington, California, and Colorado have issued policies that largely follow these guidelines. Such restrictions, when fully implemented, will lead to pesticide guidelines for Cannabis that are arguably stricter than for most other crops. This is as it should be, both for regulatory purposes, as explained above, and for safety reasons. Cannabis is used for medical purposes, and exposure to pesticides on Cannabis will be via inhalation. The dangers of pesticides on Cannabis are simply greater than they are on food crops.

Consideration of the language on the product label is not, on its own, an adequate criterion for determining which pesticides can be tolerated on Cannabis. Currently Washington and Colorado allow for the application of some pesticides (including pyrethrins, pyriproxyfen, pyridalyl, fenoxycarb, triticonazole and thiophanate-methyl) that have permissive language on their labels, but are *not* exempt from EPA tolerances. Since the EPA has established tolerances for these compounds in other food crops this policy may be problematic since it has the potential to expose consumers to unacceptable levels of these compounds.

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Given the concerns discussed above it is the position of the Cannabis Safety Institute that for the time being states should adopt policies restricting pesticide use on Cannabis to those products that are listed as minimal risk under FIFRA Section 25(b); have broad and non-exclusive language on their labels; and, in addition, are considered acceptable for use in organic practice.

A deep body of knowledge is available on sustainable and organic farming practices, including careful and detailed studies on the pests associated with Cannabis and biocontrol methods for addressing them. Biocontrols include predatory insects and beneficial microorganisms, and have been used successfully in large commercial Cannabis production facilities, such as the one operated by GW Pharma in the UK (David Potter, GW Pharma, personal communication).

Despite the clear benefits of completely organic and biocontrol-based methods of pest management, we recognize that it will take the Cannabis industry some time to transition to better practices. Pesticide use is ubiquitous in US agriculture, and we do not expect it to go away entirely. But it must be done safely, and it must be done legally. At present, it is not clear how to apply either of these standards to pesticide use on Cannabis, and so we recommend caution in both respects. Pesticide use on typical crops is allowed because it is done in the context of strict EPA-determined tolerances for each compound on each product. The process of determining these tolerance limits is complex, time-consuming, and data-driven. We do not take the position that all pesticide use is necessarily a public health hazard. Nonetheless, until a scientifically valid process for determining tolerances on Cannabis is established, we cannot assume that any level of inhalation exposure is safe for pesticides that currently have toxicology-based tolerance limits set for food products

Until the supply chain for plant cuttings is modernized, plant pests and diseases will be an extremely serious problem for growers. If states are to address this problem effectively they have to take into account the realities of how the industry is currently structured. This means taking steps to encourage a more pest-free supply chain, as well as encouraging interaction with state universities and health and agriculture departments. Above all, it means assembling regulations that give growers clear rules and guidelines, and implementing a system for effective enforcement. Putting such structures in place will require states to engage with scientific and regulatory issues that have normally been handled at the federal level. However, failing to do so will jeopardize public health, and potentially stall or reverse the growth of this new agricultural industry altogether.

At present, safety standards are enforced in the Cannabis industry through batch-testing performed by a network of Cannabis testing labs. This is not typical for agricultural products, but it reflects the reality that exists without federal oversight and structure. If managed correctly, third-party batch testing will support safety levels in the Cannabis industry that are at least as rigorous as those in place for other crops.

Cannabis testing laboratories must be supplied with clear instructions on which pesticides to test for. These laboratories must be certified to nationally and internationally accepted standards, such as ISO 17025 or NELAC, and they must be subjected to regular inter-lab

proficiency testing to ensure that their instrumentation, staffing, and protocols are adequate for pesticide testing on Cannabis flowers and concentrates. Cannabis growers and retailers need to be prepared for the fact that pesticide testing is more expensive than other safety tests they are currently required to undergo. Analyte lists should be developed with this in mind, and be kept as minimal as possible to reduce costs, while still ensuring adequate coverage of potentially dangerous compounds.

Appendix 1 contains a list of analytes that the Cannabis Safety Institute currently recommends be tested for on Cannabis. It was developed from an initial list of more than 3000 compounds registered as pesticides, and through a precise set of criteria shortened to 123 compounds. These criteria were based on toxicology, availability, and use-case potential. It is not feasible for Cannabis testing labs to test for more compounds than this; even 123 may be too many targets for the market to bear, and the price of such assays is an unavoidable issue if pesticide testing is to be required on every single batch of Cannabis. We recognize that developing a manageable and appropriate list of target compounds is complicated and ultimately requires the additional input of expert toxicologists, agricultural chemists, and regulators. Nonetheless, this list is a rational starting point. If state regulators wish to expand or contract it, they will have to engage their agriculture departments in the work of evaluating each compound independently.

Appropriate tracking systems need to be established to prevent materials that are contaminated with pesticides from being sold to the public. We suggest that the limit for all of these compounds be set to 100 ppb, as was done by the Oregon Health Authority. In the absence of specific data for each of these compounds on Cannabis, 100 ppb is a reasonable compromise. It is low enough to avoid toxicity, and at the same time it is as low a detection limit as can reasonably be achieved with the instrumentation that is available to most Cannabis testing laboratories. We also realize that, due to difficulties in detection, the limits for certain compounds may have to be increased. Testing guidelines such as these should not be implemented in statute; they should be set by rule-making bodies that can adjust them flexibly as new data becomes available.

Although regulations and enforcement may be the initial priority, long-term solutions will need to include a great deal of education and research. Land-grant universities must be allowed to do extension work and educational programs with Cannabis growers. State agriculture departments must engage with the industry and begin generating tolerance data. If state governments intend to nurture an entirely new agricultural industry without federal assistance or guidance, they must be prepared to do all the critical public health and safety work that is typically done by the federal government.

5a. Resources

Further resources regarding pesticides can be found at these locations:

- Organic Materials Review Institute (OMRI), www.omri.org
- Washington State Department of Agriculture (WSDA).
www.agr.wa.gov/FoodAnimal/CleanGreen/MaterialsLists.htm
- National List of Allowed and Prohibited Substances
www.ams.usda.gov/NOP/NOP/standards/ListReg.html
- ATTRA has a new Ecological Pest Management, on-line pest management tool for farmers. This database highlights reduced risk materials that can be integrated with ecological pest management strategies. It can be found at the following link:
http://www.attra.org/attra-pub/biorationals/biorationals_main_srch.php
- Pesticide Use in Marijuana Production: Safety Issues and Sustainable Options, Feldman, Pesticides and You, 34(4), 2014-15:
www.beyondpesticides.org/dailynewsblog/?p=15424

5b. Summary of Recommendations

- State regulators should instruct agriculture departments and universities to develop data and provide science-based recommendations about pesticide tolerances, application, and exposure on Cannabis.
- State regulators should encourage engagement in the Cannabis industry by universities and state agriculture departments, in order to educate Cannabis growers on sustainable pest control methods.
- Third party organic certification should be encouraged and supported.
- Independent Cannabis testing labs must be accredited to ISO 17025 or NELAC standards, and subject to regular inter-lab proficiency testing to ensure they are capable of accurate and reproducible pesticide testing.
- State regulators must provide independent Cannabis testing labs with clear guidance on what compounds to test for. At present, we recommend that these labs test all batches of Cannabis for the compounds listed in Appendix 1, and additional ones as found necessary. All samples with residues of these compounds detectable at over 100 ppb should be failed.
- State regulators must provide clear information about acceptable pesticide usage to Cannabis growers. Growers should be informed that the only acceptable pesticides are those that are listed as “minimum risk” in FIFRA 25(b), exempt from EPA tolerances, and acceptable for use in organic practice.

References

1. McPartland, J. M. Cannabis pests. *Journal of the International Hemp Association* (1996).
2. McPartland, J. M., Clarke, R. C. & Watson, D. P. *Hemp Diseases and Pests*. (Elsevier, 2000).
3. Sullivan, N., Elzinga, S. & Raber, J. C. Determination of pesticide residues in cannabis smoke. *J Toxicol* **2013**, 378168 (2013).
4. Stone, D. *Regulatory Toxicology and Pharmacology*. 1–6 (2015).

Appendix 1: Target list of pesticides to be screened for on Cannabis.

In an attempt to formulate a list of pesticides that cannabis should be screened for we must consider many factors including: regulatory status, toxicity, likelihood of use, and cost of analysis. Our goal in this case was to apply a set of standards that are transparent and rational. We took as our starting point the entire list of 3190 compounds listed in the Pesticide Action Network (PAN) database (pesticideinfo.org). We then applied various criteria (outlined below) to reduce this set to a more manageable list of compounds. The table below explains each of these criteria, and indicates how they contributed to the filtering process. The list on the following page contains the pesticides remaining at the end of the process. All Cannabis flowers and concentrates should be screened for these target compounds.

Step	Criteria	Justification	Number After filter
1	Full PAN database	The PAN DB is a generally comprehensive and well-curated database of pesticides.	3190
2	Exclude compounds that are not registered for use in the US	Although legacy and foreign compounds may be in use the likelihood of use is much lower than for products that are commercially available.	786
3	Exclude Section 25(b) listed	Although registered as pesticides these compounds are subject to a general exemption from tolerances	772
4	Filter on "Use" term: Include compounds containing term: insecticide, fungicide, PGR, IGR, or synergist	Exclude compounds that are less likely to be of concern or are less likely to be used on Cannabis including: herbicides, adjuvents, avicides, nematocides, molluscicides, rodenticides, fumigants, and wood preservatives.	517
5	Filter on chemical class: exclude solvents, soaps, biologicals, metals, inorganic, dithiocarbamates, and other compounds not amenable to standard MRM.	These are compounds that are generally considered low toxicity and/or are not amenable to standard multiresidue methods (MRMs).	252
6	Include compounds that have been detected ¹ , compounds that are likely to be used based upon discussions with growers or in cannabis blogs, compounds that have a toxicological concerns, or are listed as PAN bad actors ² .	These represent compounds for which there is evidence of use and/or have toxicological or environmental concerns.	123

¹ Detected by OGA, Ric Cuchetto, Pacific Agricultural Laboratory, or in literature

² Definition of "PAN Bad Actor" from PAN web site: "chemicals that are one or more of the following: highly acutely toxic, cholinesterase inhibitor, known/probable carcinogen, known groundwater pollutant or known reproductive or developmental toxicant."

TARGET LIST

2-EEEBC	D-Allethrin	Indoxacarb,S-isomer	Propoxur
Acephate	Daminozide	Iprodione	Pymetrozine
Acetamiprid	DDVP (Dichlorvos)	Kresoxim-methyl	Pyrethrins
Aldicarb	Deltamethrin	Malathion	Pyridaben
Amitraz	Diazinon	Mefenoxam	Resmethrin
Ancymidol	Dicofol	Mepiquat_chloride	S-Bioallethrin
Avermectin	Dicrotophos	Metalaxyl	Spirodiclofen
Azinphos-methyl	Dimethoate	Methidathion	Spiroxamine
Azoxystrobin	Diphenylamine	Methiocarb	Tau-fluvalinate
Bifenazate	Dodine	Methomyl	Tebuconazole
Bifenthrin	Emamectin_benzoate	Methyl_parathion	Tefluthrin
Bromuconazole	Endosulfan	Metofluthrin	Temephos
Captan	Esfenvalerate	Myclobutanil	Terbufos
Carbaryl	Ethephon	Naled	Terrazole
Carbofuran	Ethofenprox	Nithiazine	Tetrachlorvinphos
Carboxin	Ethoprop	Octhilinone	Tetraconazole
Chlorethoxyphos	Etoxazole	Oxamyl	Thiabendazole
Chlorfenapyr	Fenazaquin	Oxydemeton-methyl	Thiacloprid
Chlormequat_chloride	Fenitrothion	Paclobutrazol	Thiamethoxam
Chlorothalonil	Fenoxycarb	Para-dichlorobenzene	Thiodicarb
Chlorpyrifos	Fenpropathrin	Permethrin	Thiophanate
Chlorpyrifos-methyl	Fenpyroximate	Phorate	Tolyfluanid
Coumaphos	Fipronil	Phosmet	Tralomethrin
Cyclanilide	Folpet	Phostebupirim	Triadimefon
Cyfluthrin	Formetanate_hydrochloride	Piperonyl_butoxide	Triadimenol
Cyhalothrin,lambda	Fosetyl-Al	Pirimiphos-methyl	Tribufos
Cypermethrin,beta	Hexythiazox	Prallethrin	Trichlorfon
Cypermethrin,zeta	Hydramethylnon	Profenofos	Trifloxystrobin
Cyphenothrin	Hymexazol	Propargite	Triforine
Cyproconazole	Imazalil	Propetamphos	Vinclozolin
Cyromazine	Imidacloprid	Propiconazole	