# Economic Value of the Herbicide Dacthal for Brassica and Allium Crops in California

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**California review of the herbicide dacthal triggered by the requirements of California's Pesticide Contamination Prevention Act was conducted in 2018. This article estimates the economic effects a cancellation of dacthal's California registration would have on brassica and allium crops. Statewide net revenue losses for broccoli, dry onion, and cabbage, the largest users of dacthal, are estimated at $25.4 million: $17.9 million for broccoli, $2.4 million for cabbage, and $5.1 million for onion.**

Broccoli alone accounted for 40% of pounds of dacthal applied in 2014–2016 in California, and almost half of treated acreage.

A review of dacthal (aka chlorthal-dimethyl or DCPA) was initiated in early 2018 by the California Department of Pesticide Regulation (DPR) due to the detection of its degradates in groundwater. Under California's Pesticide Contamination Prevention Act, the confirmed detection of a pesticide active ingredient or degradation product in groundwater, which arises from legal agriculture use, automatically triggers a review. The purpose of the formal review is to determine whether or not the pesticide can continue to be used and, if so, under what conditions. One of the considerations in the review is whether or not a regulatory response would cause "severe economic hardship" for California agriculture.

This article evaluates potential economic impacts for brassica and allium crops if the California registration for dacthal was canceled. It is derived from a larger report prepared for consideration in the review process. Ultimately, DPR determined that the level of dacthal degradates was below the level of toxicological concern. If this had not been the case, economic impacts would have been considered as part of the regulatory response required to reduce pollution. Groundwater monitoring for dacthal and its degradates will continue, and DPR will continue to review new research that could alter these review findings.

## Background

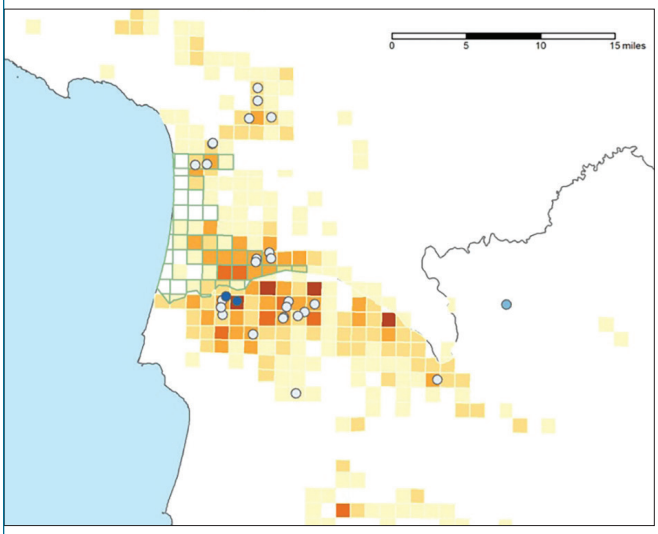
Dacthal is a selective pre-emergence herbicide used for controlling annual grasses and certain broadleaved weeds. The value of dacthal is its long list of crop registrations and excellent selectivity on a large number of crops in the allium (onion family) and brassica (mustard family) crops, which account for the majority of dacthal use. These crops have few alternative herbicides with similar selectivity and efficacy. Broccoli alone accounted for 40% of pounds applied in the 2014–2016 period, and almost half of treated acreage. Other brassica crops, such as cauliflower, and allium crops, such as dry onion, accounted for slightly more than half of total pounds applied and over 40% of treated acreage. Table 1 reports dacthal applications for brassica and allium family crops as well as all other uses, which were primarily nursery uses and acreage reported as uncultivated or without a crop specified.

A key concern regarding the availability of dacthal is the fate of small acreage brassica crops dependent on dacthal: bok choy, Brussels sprout, radish, kale, rapini, mustards, gai lon, and kohlrabi. Oxyfluorfen is not

**Table 1**. Dacthal Use by Pounds Active Ingredient Applied and Acres Treated: 2014–2026

| | ---------Pounds AI Applied------- | | | ----------Acres Treated---------- | | |
|---|---|---|---|---|---|---|
| | 2014 | 2015 | 2016 | 2014 | 2015 | 2016 |
| Brassica | 137,040 | 124,375 | 128,036 | 37,114 | 31,967 | 35,388 |
| Allium | 44,350 | 52,230 | 54,141 | 8,540 | 9,265 | 9,288 |
| Other | 7,872 | 7,465 | 6,762 | 1,803 | 1,378 | 1,232 |
| Total | 189,262 | 184,070 | 188,939 | 47,457 | 42,610 | 45,908 |

**Figure 1.** Long-term Dacthal Use Trends and Detections of Dacthal Degradates in Groundwater in the Santa Maria Area*




*Squares represent 1 mile x 1 mile sections that contain previous dacthal use and/or GWPAs. Blue circles represent approximate locations of dacthal degradate groundwater detections.

registered for these crops. Alternative active ingredients such as bensulide and trifluralin provide less effective weed control and/or have long residuals that could interfere with rotational crops common to these cropping systems. Dacthal, in contrast, can be used on many crops and has a short life in the soil, so carryover injury to rotational crops is not an issue.

## Dacthal and Groundwater

Dacthal use and detections of its degradates are associated with the Central Coast production areas for Brassica and allium crops. High detections of dacthal degradates in well water in parts of San Luis Obispo, Santa Barbara, and Monterey counties were observed prior to the review. Monterey County alone accounts for about a third of all pounds of dacthal applied, and slightly under half of all acreage treated. Together, San Luis Obispo and Santa Barbara account for around another 10% of pounds applied and 8% of acres treated.

Figure 1 maps long-term dacthal use, whether a focal crop was grown, and detections of dacthal degradates in groundwater in the Santa Maria area in San Luis Obispo and Santa Barbara counties. The highest dacthal use in the area (over the period 1990-2016) occurred south of the Santa Maria River near the community of Guadalupe in Santa Barbara. Figure 2 presents the same information for the Salinas Valley. The highest detections are located near Greenfield.

## Approach

The economic impact of a deregistration or other pesticide regulation is determined by its effects on costs, yield, price, and acreage for affected crops. Cost and yield effects depend directly on the chemical and non-chemical alternatives that are available and their prices and efficacy compared to the pesticide being considered for deregistration.

If yield declines, gross revenue will decline. However, if the change in quantity at the industry level is sufficiently large, price may increase, which would partially offset the effect of reduced yield on revenue. Price would only respond to a change in quantity if the industry-level demand was less than "perfectly elastic." If demand is perfectly elastic, then the price does not change when the quantity supplied changes.

If there are many good substitutes for a crop for consumers and if there are competing producers who can expand output, then the price of a crop will respond less to a given decline in quantity than it would if a crop had few substitutes in consumption and few competing producers. These changes in costs and revenues will affect net returns per acre. Growers may choose to plant fewer acres of the affected crop, which would reduce industry quantity still more and increase price if demand was less than perfectly elastic.

We separate the economic impact of a dacthal deregistration for a crop into four factors: (i) changes in herbicide material costs, (ii) changes in application costs, (iii) changes in hand-weeding and cultivation costs, and (iv) changes in yield, which affect gross revenues.

An overarching challenge is that dacthal does not have a direct substitute and thus one or multiple possible replacement herbicides may provide only partial spectrum of control relative to dacthal. Further, the available set of possible replacement herbicides that are registered depends on the crop in question.

To calculate (i), we begin by identifying one or multiple possible replacement herbicides. The change in material cost is then determined by the amount of material required to achieve a spectrum and level of control as close to dacthal as possible, as well as the price difference between dacthal and the chosen potential replacements. To calculate (ii), we determine if the identified replacement(s) would require changes in the number of applications conducted and thus incur additional application costs. Regarding (iii), additional hand-weeding and/or mechanical cultivation may be needed. Finally, to account for the fact that replacement herbicides may not provide complete

control relative to dacthal, we calculate (iv) based on an expected yield loss, if any, of incomplete control and current output prices. Given crop-level values for (i)–(iv), we calculate the total economic impact of a dacthal prohibition as the product of the change in per-acre cost for each crop from (i)–(iv) and the number of acres planted to each crop treated with dacthal.

Prior to initiating the analysis, we identified crops that would be most likely to sustain economic losses if dacthal was deregistered: brassica and allium crops. Then we focused attention on determining the crops for which sufficient information was available to conduct the analysis. Pesticide use data were obtained from the DPR Pesticide Use Reporting (PUR) database. Specifically, we collected the amount of active ingredient and treated acreage from 2014 to 2016 from the PUR database for dacthal and all possible replacement herbicides.

Based on this information, 14 brassica and allium crops were identified that used dacthal in that time period and would be impacted by its loss. Ordered by decreasing total pounds of active ingredient applied, the crops are: broccoli, dry onion, cabbage, cauliflower, Chinese cabbage, bok choy, Brussels sprout, kale, rapini, mustard, leek, gai lon, kohlrabi, and green onion.

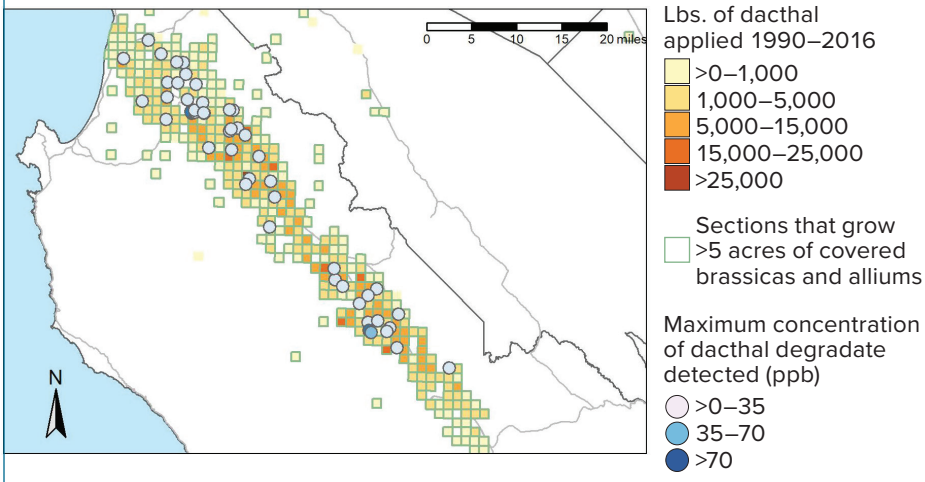
Crop acreage, production, and price data were obtained from the CDFA annual report. This information was not available for bok choy, rapini, mustard, and gai lon, eliminating them from the analysis. University of California cost studies for broccoli, dry onion, and cabbage were used to provide a baseline for hand-weeding and mechanical cultivation costs and calculate changes in these costs.

Cost studies were not available for seven crops, so only the effects of changes in pesticide costs and yield were included in the computation of the anticipated change in net returns for cauliflower, Chinese cabbage, Brussels sprout, kale, leek, kohlrabi, and green onion. Data limitations mean that the estimate of economic losses is a lower bound for two reasons: not all crops are included, and not all costs are included for most of the remaining crops.

We assume that acreage in each crop remains unchanged. We also assume that demand for these California crops is perfectly elastic. Many of the crops are very minor ones that have multiple close substitutes for consumers. Furthermore, not all acreage utilizes dacthal, dampening industry-level average yield losses and any associated price response. Ex ante, these factors imply that any price increase will be small in response to a given percentage decrease in production.

An offsetting consideration is that California is a major producer, in some cases the only U.S. state with non-negligible production, so that a change in California's output is likely to affect price unless foreign competitors increase production. Any such price increase would reduce losses compared to those reported here.

**Figure 2.** Long-term Dacthal Use Trends and Detections of Dacthal Degradates in Groundwater in the Salinas Valley Area*




*Squares represent 1 mile x 1 mile sections with that contain either previous dacthal use and/or GWPAs. Blue circles represent approximate locations of dacthal degradate groundwater detections.

## Results

We focus on changes in net returns for the three crops for which we have information on baseline hand weeding and mechanical cultivation costs: broccoli, dry onion (henceforth onion), and cabbage. Based on the assessment of efficacy presented in the previous section, plus the availability of alternatives given current product registrations, a single alternative active ingredient was selected for each crop. In practice, specific weed problems will influence growers' choice of an alternative pesticide or pesticides, and a variety of herbicides are applied to these crops. PUR data were used to identify a "representative" product for each alternative in order to compute the change in pesticide material costs. Based on product labels and other information, we determined that the alternatives would most likely be applied the same way as dacthal is, so there would be no change in application costs. For broccoli and cabbage, oxyfluorfen (represented by GoalTender) is a partial alternative. For onion, pendimethalin (represented by Prowl H2O) is a partial alternative. While there is substantial use of oxyfluorfen, it does not address early season needs during onion emergence and establishment.

The second step in the analysis is to identify changes in costs and yields. The pesticide material cost per acre of these alternatives is less than the cost of dacthal. Its significant use suggests that differences in yield and other costs are important factors in growers' herbicide use. In the absence of dacthal, hand weeding costs will increase because replacement products do not control weeds as well as dacthal. Based on estimates from UC Cooperative Extension personnel, we assume a 40% increase. Regarding mechanical cultivation, UC cost studies for both organic and conventional broccoli report identical mechanical cultivation costs. In the absence of an organic cost study for cabbage, we assume that mechanical cultivation costs are unchanged, as for broccoli. For onion, we estimate early season cultivation costs will increase by 70%. Based on UC Cooperative Extension estimates, UC cost studies, and the scientific literature, we estimate that there will be a 10% yield loss. If additional hand and mechanical weeding were used exclusively, yield losses would likely be at least 10% owing to the increased need for cultivation and hand weeding, which will damage the delicate crop feeder roots.

Under these specifications, net revenues per acre for broccoli would decrease by $834. Net returns per acre for cabbage would decline by $1,017. Net returns per acre for onion would decline by $590. Information in the cost studies enables us to compare these changes in net revenue to overall net revenue per acre. For broccoli, net returns per acre decreased by 62%. Net returns per acre for onion decreased by fifteen%. Net returns per acre for cabbage decreased by 85%.

If prices are unchanged, the corresponding reductions in statewide net revenues would be $17.9 million for broccoli, $2.4 million for cabbage, and $5.1 million for onion, totaling $25.4 million.

## Additional Crops

If DPR had found it necessary to regulate dacthal, there are other regulatory options available. A regional ban or specific use regulations could reduce the impact by focusing on areas with high levels of degradates. Alternatively, dacthal could be added to DPR's groundwater protection list and new groundwater protection areas could be created in order to reduce leaching potential and enhance monitoring and oversight.

Non-regulatory options include enhancing the efficacy of existing alternatives, such as the use of "intelligent" cultivators to reduce hand weeding costs, and pesticides not currently registered for affected crops. One specific possibility would be to screen all brassica crops for tolerance to S-metolachlor (e.g., Dual Magnum). This herbicide active ingredient is gaining many registrations for vegetables and may be helpful for transplanted brassica crops like bok choy. Another would be to expand the set of crops for which oxyfluorfen is registered. Another relatively new herbicide for brassica vegetables is sulfentrazone (Zeus).


### Authors' Bios

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### For additional information, the authors recommend:

California Department of Pesticide Regulation. "Pesticide Contamination Prevention Act Review Process Triggered by Detections of Chlorthal Dimethyl in Ground Water." www.cdpr.ca.gov/docs/emon/grndwtr/chlorthal_dimethyl/chlorthal_dimethyl.htm.