OFFICE OF CHEMICAL SAFETY AND POLLUTION PREVENTION

WASHINGTON, D.C. 20460

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MEMORANDUM

SUBJECT: Mancozeb (PC# 014504) Registration Review: Assessment of Use, Usage, Benefits and Impacts of Potential Mitigation for Foliar Uses in Apples, Pears, Almonds, Walnuts, Mango, Papaya, Grapes, and Cranberry

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Summary

Mancozeb is an ethylene bisdithiocarbamate multi-site protectant fungicide that belongs to FRAC (Fungicide Resistance Action Committee) code M03 based on its mode of action. This memorandum describes the use, usage, benefits, alternatives, and potential impacts from mitigation for mancozeb use in apple, almond, cranberry, grapes, mango, papaya, pears, and walnuts. BEAD finds that mancozeb provides high benefits in apple, pear, walnut, grape (eastern states), papaya and cranberry growers.

BEAD finds that mancozeb provides high benefits in apple and pear production due to its role in managing resistance to other fungicides. Without mancozeb, growers would apply more single-site fungicides with greater frequency to obtain season-long control of scab, increasing the likelihood that resistance would develop. Benefits are also high in walnut and papaya where mancozeb is used for control of walnut blight and Phytophthora fruit and stem rot in papaya. Copper is a less effective alternative so in the absence of mancozeb growers could incur yield or quality losses. BEAD also finds high benefits to the use of mancozeb in grape production in eastern states where conditions are conducive to black rot as captan is less effective and sole reliance on single-site fungicides for control would likely result in resistance developing in black rot. There are also high benefits to the use of mancozeb in cranberry production in the Northeast. In cranberry, one application of mancozeb per year is important for growers because under high disease pressure of fruit rot disease the growers need a minimum of three applications of multisite fungicides (chlorothalonil and mancozeb) and chlorothalonil can only be applied two times due to new proposed new annual limit.

BEAD finds moderate benefits of mancozeb use in mango. Without mancozeb, growers may have to make more frequent applications of single-site fungicides at some increase in cost but can likely maintain resistance management programs with the use of chlorothalonil. Almonds were determined to have low benefits because multiple multisite fungicide alternatives are available to almond growers.

The benefits of the use of mancozeb in other registered pome fuit (crabapple and quince), tropical fruits (banana, plantain, sugar apple, cherimoya, atemoya, custard apple, sweetsop, star apple [caimito], canistel, mamey sapote, sapodilla, white sapote), and caprifig are unknown. Information is lacking on target pests and the availability and adequacy of alternatives.

The EPA has identified risks to occupational handlers (mixers/loaders and applicators), bystanders, and to non-target organisms (ecological risks) associated with the use of mancozeb.

The Agency is considering reducing occupational handler worker exposure risks through:

- Requiring use of APF10 respirators and additional personal protection equipment (PPE) for mixers, loaders, and applicators when utilizing any mancozeb formulation. The primary burden is the cost to obtain an annual fit test of the APF10 respirator and the potential for heat stress on workers which can result in more frequent breaks and can increase the time and labor cost of utilizing mancozeb; and
- Closed loading system for mixers and loaders when utilizing dry flowable and wettable powder (DF and WP) formulations, which may entail the requirement that these formulations come in closed packaging that can be inserted into water in a pesticide delivery system and mixed with the container closed. This will increase packaging costs and may also require that applicators utilize equipment that can agitate or mix while the system is closed. Costs of mancozeb use will therefore increase if this requirement were to apply. While growers could opt to switch to utilizing a liquid formulation, it is currently may be double the cost of the DF formulation on a per acre basis; and
- Requirement to use an enclosed cab for airblast applications. This is anticipated to be costly for applicators who do not already have the appropriate equipment, particularly for growers operating fewer acres as they have fewer acres over which to spread the fixed cost of enclosed cab purchase or retrofitting upgrade. Alternatively, growers could hire a commercial firm with the equipment to make mancozeb applications however this would also increase grower costs; and
- Prohibiting use of mechanically pressurized handguns. Prohibiting mechanically pressurized handgun use for mancozeb is anticipated to have minimal impacts but may impact papaya growers in Hawaii who rely on this method of application of mancozeb to drench papaya tree trunks.

The Agency is considering addressing post-application worker exposure risks through:

- Cancelling use of mancozeb on grapes. If mancozeb is unavailable in grape, growers would have to rely on more single site fungicides to control black rot which would compromise resistance management of this disease.
- Extending the restricted entry interval (REI) by up to four days. A 4-day REI is not anticipated to be highly disruptive or impactful to current production practices in these crops. However, it would require that operators post warning signs, which could be an additional burden in time and labor.
- Prohibiting hand thinning in orchard crops. A prohibition on hand thinning is expected to impact only those apple and pear growers managing high-value varieties where hand thinning may be utilized; hand thinning is not anticipated to be a practice that is done in a commercial apple or pear production. A prohibition of hand thinning may be de-facto cancellation for papaya but is not anticipated to impact mango growers as hand thinning is not anticipated to be done in mango; and

The Agency is considering addressing bystander and ecological risks through:

- Spray drift mitigation (i.e., windspeed restrictions to 10 mph, increased droplet size, and buffers). Windspeed restrictions reduce grower flexibility when making a pesticide application. A medium droplet size is anticipated to be acceptable for growers utilizing mancozeb, but larger droplets could reduce coverage and efficacy. Buffers may mean that growers have to treat a portion of the field with different fungicides or leave the area untreated. If growers cannot apply mancozeb in buffer areas, then they would need to utilize another multisite fungicide, if applications are available, or utilize more single site fungicides which could compromise resistance management. The overall effect will vary depending on the size of the buffer and the size of the field affected.
- Prohibiting mancozeb applications 48-hours ahead of any projected rain event that is likely to result in runoff. This potential restriction on applications prior to rainfall to be highly impactful to users of mancozeb. Applications of mancozeb need to be made ahead of a rain event because pathogens thrive in wet weather and increases pest pressure. The increase in pest pressure has a potential to cause disease spread and ultimately high yield losses.
- Requiring that growers obtain and follow additional mitigations in Bulletins Live! Two ahead of pesticide application. Even though this web-based system has been in place for many years, the requirement that growers access and follow Bulletins is relatively new. Therefore, users may face a learning curve when becoming acquainted with the system. Moreover, growers may be subject to additional and potentially more stringent mitigation measures than those described in this memo which can require significant planning and may be costly to implement and maintain.

Introduction

Mancozeb is a broad-spectrum protectant fungicide registered for use on agricultural and non-agricultural use sites. The Federal Insecticide Fungicide and Rodenticide Act (FIFRA) Section 3(g) mandates that the Environmental Protection Agency (EPA or the Agency) periodically review the registrations of all pesticides to ensure that they do not pose unreasonable adverse effects to human health and the environment. This periodic review is necessary in light of scientific advancements, changes in policy, and changes in use patterns that may alter the conditions underpinning previous registration decisions. In determining whether adverse effects are unreasonable, FIFRA requires that the Agency consider the risks and benefits of any use of the pesticide.

The Agency has identified risks to bystander risks, occupational handlers (mixer/loaders and applicators) and occupational post application risks as well as ecological risks associated with mancozeb use in some orchard crops (apple, pear, walnut, almond, mango, and papaya), grapes and cranberry. To address occupational handler risks, the Agency may consider requiring the use of personal protective equipment (PPE) and/or engineering controls as well as prohibiting use of certain application methods (i.e., mechanically pressurized handguns). Engineering controls include requirement that dry flowable and wettable formulations be offered in water soluable packets (closed loading) when mixing for aerial and chemigation applications to mitigate risks to mixer/loaders. Engineering also include requirement to utilize an enclosed cab when making airblast applications of mancozeb. Post application occupational risks may be mitigated with an increased restricted entry interval (REI) or in the case of grapes, prohibiting use of mancozeb. To address bystander and ecological risk, the Agency could require steps to reduce spray drift (e.g., restrictions on droplet size, boom height, allowable windspeed). Additional ecological mitigations include those that reduce runoff risk (e.g., rain restrictions).

The purpose of this document is to assesses use, usage and benefits of mancozeb and impact of potential mitigation to growers in apple, pear, almonds, walnut, mango, papaya, grapes, and cranberry. In addition, the impacts of potential mitigations to reduce identified risks will be discussed. BEAD also assessed the usage and benefits of mancozeb on other agricultural and non-agricultural crops, including seed treatment uses, in separate memorandums. These memorandums are available in the mancozeb docket (EPA-HQ-OPP-2015-0291) at www.regulations.gov.

Methodology

The benefits of mancozeb to the user are based on various agronomic factors, chemical characteristics of mancozeb, and alternative control strategies, which influence how a grower chooses to manage pests and to what extent mancozeb is important to the user. The unit of analysis is an acre of a particular crop that would normally be treated with mancozeb. BEAD assesses benefits at this unit of analysis both because crop growers make pest control decisions at the acre- or field-level, and because risks are usually measured at the same spatial levels (treated acres and treated fields).

BEAD evaluates mancozeb usage data to identify use patterns, including variations in regional and seasonal usage such as average application rate, frequency of application, and methods of application. Also summarized for each crop are major production regions within the United States. BEAD also reviews data on pesticide usage and existing scientific publications to identify the important target pests and the attributes of mancozeb that make it useful in the pest control system. Together, this information establishes where, when, and how growers use mancozeb.

BEAD then evaluates the magnitude of benefits by assessing the biological and economic impacts that the grower might experience should they need to employ alternative pest control strategies in the absence of mancozeb. BEAD identifies the likely alternative control strategies by reviewing extension recommendations, grower surveys, and considering economic factors. Impacts to a grower using the next best alternative to mancozeb include monetary costs (e.g., from using more expensive chemicals) as well as loss of utility in resistance management, simplicity of use, flexibility, management, and/or integrated pest management programs). There may also be impacts with respect to crop yield loss and/or quality reductions related to diminished pest control.

A similar approach is followed to assess the impacts of possible mitigations on the use of mancozeb to reduce risks. BEAD considers how the potential restrictions would affect the ability of users to control pests or affect the costs of using mancozeb.

For these analyses, data are sourced from university extension services, United States Department of Agriculture (USDA) (e.g., publicly available crop production, pesticide usage, and cost data as well as information submitted directly to EPA), public and commercially available grower survey data, public comments submitted to the Agency from various stakeholders, and BEAD's professional knowledge. When available, robust pesticide usage data is provided from Kynetec USA Inc, a private research firm, which provides pesticide usage data on approximately 60 crops collected annually through grower surveys using a statistically valid approach.

Chemical Characteristics

Mancozeb is an ethylene bisdithiocarbamate broad spectrum multisite protectant fungicide in the FRAC group M03 (FRAC, 2024). Mancozeb is a complex of two other dithiocarbamate fungicides, maneb and zineb, neither of which are registered outside of their combined molecule mancozeb. Mancozeb, as a multisite fungicide, works by deactivating multiple essential enzymes and amino acids in the cells of target pathogens. Due to these multiple pathways for inhibiting disease development, mancozeb, like other multisite fungicides, has a very low risk of resistance development (FRAC, 2010; FRAC, 2018) is classified as a multisite fungicide. Multisite fungicides, including mancozeb, typically have a broad spectrum of activity, and mancozeb's broad spectrum of activity prevents diseases caused by bacteria, fungi, and oomycetes on seed and in the field.

Use and Usage

Use

Mancozeb is a broad-spectrum contact fungicide registered for use on a variety of agricultural crops, including various fruits and nuts. Mancozeb is registered for use in apple, almond, crabapple, cranberry, grapes, pear, quince, walnut, and certain tropical and subtropical fruits (banana, plantain, mango, papaya, sugar apple, cherimoya, atemoya, custard apple, sweetsop, star apple [caimito], canistel, mamey sapote, sapodilla, white sapote). Mancozeb is also registered for use on caprifig as a dip treatment for mamme figs used in cross pollination.

Mancozeb formulations for use on apple, almond, crabapple, cranberry, grapes, pear, quince, walnut, mamme figs, and tropical and subtropical fruits include dry flowables (includes water dispersible granules), flowable concentrates (liquid), and wettable powders that are applied via broadcast (ground and aerial) or chemigation.

Usage

Mancozeb usage presented in Table 1 and summarized in this section are national 5-year annual averages (2017 – 2021). Nationally, about 2,300,000 lbs. of mancozeb were applied to about 1,000,000 total acres treated across all surveyed orchard crops (apple, pear, almond, walnut) and grapes, on average annually (Table 1). Walnut and apple are the two crops with the highest total acres treated, and these crops, along with pear have a high percent of acres treated. Additional information on regional usage (and in the case of grapes-regional benefits) is presented along with a discussion of benefits below. There are no recent, available, and nationally representative usage data for additional registered pome fruit (crabapple and quince), tropical and subtropical fruits (including mango and papaya), cranberry, and caprifig. The absence of such data should not be interpreted as lack of usage.

Table 1: Average annual national mancozeb usage in apple, almond, grapes (raisin, table, and wine), pear, and walnuts from 2017-2021

Crop	Percent of Crop Treated (PCT)	Total Acres Treated (TAT)	Pounds (lbs) AI Applied	Single application Rate (lbs AI/A)	Number of Applications
Walnut	53	470,000	850,000	1.8	2.1
Pear	52	55,000	240,000	4.4	2.2
Apple	36	440,000	1,100,000	2.4	3.9
Almond	≤2.5	23,000	110,000	4.5	1.0
Grapes, Raisin[1]	≤2.5	≤500	≤500	(S)	(S)
Grapes, Table[1]	≤2.5	2,100	2,600	(S)	(S)
Grapes, Wine[2]	≤2.5	2,300	3,600	(S)	(S)

Source: Kynetec 2022 a,b

[1]Note that this usage value represents California only. California raisin and table grapes account for the majority of such grape acres grown in the US, California usage on grapes is considered to be nationally representative.

[2] Note that usage on wine grapes reflects available usage in surveyed Western states (California from 2017-2021 and Washington from 2017-2018) which represent the majority of total wine grape acres grown nationally. Although mancozeb usage was not reported on wine grapes grown in Washington, wine grape acreage values are included within the PCT calculation.

(S): Insufficient number of reports to establish an estimate.

The majority of acres treated with mancozeb to apples, almonds, grapes, pears, and walnuts took place with ground application equipment (excluding chemigation and spot treatment), with about 95% or more of the TAT for each crop from 2017-2021 (Kynetec, 2022a). No grape acres were reported as treated with mancozeb by aerial or chemigation application methods from 2017- 2021 (Kynetec, 2022a). Within almonds, apples, and pears, less than 2% of TAT for each crop was treated aerially or by chemigation (2017-2021; Kynetec, 2022a). Within walnuts, about 3% of TAT were treated aerially or by chemigation from 2017-2021 (Kynetec, 202a).

The dry flowable formulation was the most widely used formulation type of mancozeb applied. From 2017-2021, at least 85% or more TAT of each crop were treated with the dry flowable formulation (Kynetec, 2022a).

The rest of this memo assesses the benefits of mancozeb use on apples, almonds, cranberry, grapes, mango, papaya, pears, and walnut. For each use site assessed in this memorandum, BEAD provides background information on crop production and pest management practices, then identifies target pests and the role mancozeb plays in control, identifies other control strategies, and describes the benefits of the use of mancozeb in comparison to a scenario without the use of mancozeb. Information on target pests and alternatives for other registered pome fruit (crabapple and quince), tropical fruits (banana, plantain, sugar apple, cherimoya, atemoya, custard apple, sweetsop, star apple [caimito], canistel, mamey sapote, sapodilla, white sapote), and caprifig is insufficient for an assessment.

Role of mancozeb and other multisite fungicides in resistance management

Multisite fungicides, such as mancozeb, work by means of a multisite inhibitor MoA. Fungicide resistance prevention and management is an important component of disease management programs because resistant pathogens can cause substantial disease outbreaks leading to epidemic levels of disease development, yield losses, and the loss of effectiveness of currently used highly efficacious single-site fungicides (FRAC, 2018). The development of resistance to a single site fungicide often results in cross-resistance to other fungicides with the same mode of action (FRAC, 2024). The loss in efficacy of any single-site fungicide to which pathogens have developed resistance can lead to heavier reliance on fewer single-site fungicides that are still effective (FRAC, 2018). Single site fungicide efficacy is critical to maintain because these active ingredients are usually systemic and highly efficacious in controlling specific diseases, and multisite fungicides play a critical role in maintaining their efficacy and delay and/or prevention of resistance. Therefore, mancozeb is often used in combination with single site MoA fungicides for season long disease control and resistance management.

Growers utilize multisite fungicides in their pest control program due to their broad-spectrum activity in controlling fungal pests and resistance management benefits. Growers typically apply fungicides every 7 - 10 days during the growing season. Growers often apply a multisite in combination or in rotation with one or more single site fungicides for more effective control of specific pests and to manage resistance to the single site fungicides. Growers may also apply the multisite alone for some applications for disease prevention and to avoid sequential applications of single sites as part of a resistance management program.

In addition, these multisite fungicides are less expensive relative to most single site fungicides (Kynetec, 2022a). In the absence of mancozeb, a grower is likely to substitute another multisite fungicide, if available, due to the above-described benefits.

Table 2 below is provided to relay which multisite fungicides are registered for the sites assessed in this document and so in the absence of mancozeb, which multisite fungicides may be available for growers to utilize. EPA has recently proposed to cancel the use of ziram and ferbam and has proposed to reduce the maximum annual application rate of chlorothalonil, which will effectively constrain the number of applications that can be made.

Table 2.: Multisite fungicide alternatives to mancozeb in different crops for foliar applications.

Crop	Chlorothalonil	Captan	Ziram [1]	Ferbam [1]	Copper	Sulfur
Tree Nuts						
Almonds	X	X			X	
Walnut					X	
Pome Fruit						
Apple		X	X	X	X [2]	X [2]
Pear			X	X	X [2]	X [2]
Tropical and Subtropical Fruit						
Mango	X			X [3]	X	
Papaya	X				X	
Grapes						
Grapes		X	X		X	X
Cranberries						
Cranberries	X			X	X	

[1] Agency has proposed cancellation of use per recent amended proposed interim decisions issued.
[2] Phytotoxic under certain conditions; preferred use is during pre-bloom.
[3] Registered in Florida only

Benefits of the Use of Mancozeb

Almonds

Nearly all production of almond (approximately 99%) in the US occurred in California in 2022 (USDA NASS, 2024a). In almonds, mancozeb is recommended and used in controlling brown rot, jacket rot, anthracnose, shot hole, scab and rust diseases (UC- Riverside, 2024). If diseases are not controlled, they can cause yield losses and quality of harvested nuts. Almond growers reported minimal mancozeb usage (≤2.5 percent) on average each year from 2017-2021 (Table 1), suggesting almond growers do not rely on mancozeb for disease control. Almond growers have access to multiple fungicides having different modes of action (including other multisite fungicides such as chlorothalonil, captan, and copper) that are recommended and effective in controlling almond diseases (UC-Riverside, 2024). Based on low percent of crop treated and availability of registered alternatives having multi-site MoA, BEAD finds low benefits of mancozeb to almond growers.

Walnut

Nearly all production of walnut (approximately 99%) in the US occurred in California in 2022 (USDA NASS, 2024a). Mancozeb was widely used on walnuts, with about 53% of walnut acres treated annually with mancozeb from 2017 to 2021 (Table 1). Walnut growers use mancozeb for control of walnut blight caused by the bacterial pathogen *Xanthomonas arboricola* pv. *juglandis* (Kynetec 2022a, Adaskaveg *et al*., 2020a). Walnut blight is the most important disease targeted by mancozeb and has been documented to cause severe foliar defoliation resulting in up to 60 percent yield loss without the use of effective disease control (Moragrega and Liorente, 2023; Ark and Scott, 1951). All green tissue, including buds, shoots, and developing nuts, is susceptible to walnut blight, which causes black lesions on infected tissue (Adaskaveg *et al*., 2020a, 2020b). Walnut blight can cause economically significant damage when developing nuts are infected, particularly during wet years because moisture increases disease transmission to new plant parts, resulting in high disease severity (Adaskaveg *et al*., 2020a, 2020b).

The University of California Integrated Pest Management Program (UC IPM) recommends that walnut growers apply protective fungicides, such as mancozeb, on a 7-to 10-day schedule starting at budding, depending on disease pressure, history of disease in the orchard and weather conditions. As shown in Table 1, on average, two applications of mancozeb are made each year. Up to 4 applications of mancozeb may be applied per year under high disease pressure (Adaskaveg *et al*., 2020a).

Mancozeb, copper and kasugamycin are recommended for controlling walnut blight (Adaskaveg *et al*., 2020a, 2020b; Adaskaveg *et al*., 2022). UC IPM recommends mancozeb, kasugamycin (FRAC 24) and copper fungicides (FRAC M01) for control of walnut blight (Adaskaveg *et al*., 2020a, 2020b; Adaskaveg *et al*., 2022). UC IPM (Adaskaveg, *et al*., 2022) recommends a mixture of mancozeb with copper or kasugamycin for excellent control of the disease. A mixture of copper fungicides with kasugamycin also provides excellent disease control (Adaskaveg *et al*., 2022). The report further shows that copper or kasugamycin alone provides good control of walnut blight disease (Adaskaveg *et al*., 2022).

Resistance management is very important in walnut blight because a limited number of bactericides are registered for controlling walnut blight. Resistance to copper has been reported (California Walnut, 2019), and kasugamycin is prone to resistance development in the pathogen due to its single site mode of action (FRAC, 2024). Therefore, walnut growers use mancozeb to control the disease and manage resistance in pathogen to copper and kasugamycin (Milliron, 2022; California Walnut, 2019; Adaskaveg *et al*., 2020b).

If unable to use mancozeb, walnut growers would likely use copper in mixture with kasugamycin for walnut blight control (Adaskaveg *et al*., 2022). As per the kasugamycin label, only 2 sequential applications can be applied and therefore growers are likely to rely on copper alone at some points during the season and could suffer yield and quality reduction. In addition, continuous use of copper may exacerbate resistance in the pathogen and further compromise disease control. Therefore, BEAD finds that mancozeb provides high benefits to walnut growers.

Apple and Pear

In 2022, there were approximately 363,000 acres of bearing apples in the US (USDA NASS, 2024a). In the West, Washington was the leading producer of apples, accounting for about 47% of bearing apple acres in the US (USDA NASS, 2024a). In the East, New York was the leading producer of apples, accounting for about 15% of US apple acres (USDA NASS, 2024a). Other notable producers of apple are Michigan, Pennsylvania, Virginia, and California (USDA NASS, 2024a). Mancozeb use is higher in eastern apple production as measured by overall percent acres treated than in the west. So even though Table 1 reports a 36 percent crop treated nationally in apples, states in the east and upper midwest reported higher percent crop treated with mancozeb in apples (e.g., 93 PCT in both New York and in Pennsylvania and 79 PCT in Michigan).

In 2022, there were approximately 46,000 acres of bearing pears in the US (USDA NASS, 2024a). Washington, Oregon, and California dominated US pear production in terms of acres of bearing pear in 2022 with 37%, 32%, and 19% of total pear acres produced in the U.S., respectively (USDA NASS, 2024a).

In apple and pear, 98% and 84% of acres treated with mancozeb during 2017-2021 were to target scab respectively (Kynetec, 2021a). The second most mentioned pest in survey data for the same period in crops, as measured by PCT, was rust. However, only 6% and 7% of acres treated with mancozeb were to target rust in apple and pear respectively. Therefore, BEAD's analysis focuses on apple scab and pear scab. Apple scab occurs everywhere in the world (including U.S.) where apples are grown and results in more losses than any other apple disease. It is most serious in areas that have cool, wet spring weather and may not be economically important in warm and/or dry climates (Gauthier, 2018). Pear scab is also important (Spotts and Castagnoli, 2010).

To control scab in apples and pears, growers apply fungicides beginning in the early season and repeat throughout the growing season at an interval of seven to ten days (Koetter and Grabowski, 2019; Pscheidt and Ocamb, 2022). This means that BEAD anticipates that apple growers are utilizing 12 to 16 fungicide applications in total over the course of the growing season with multi-site fungicide applications likely accounting for at least half of the applications.

Scab disease is caused by *Venturia* spp. (Pscheidt and Ocamb, 2022) and mancozeb is recommended to control the disease (Cortens, 2021). Mancozeb is applied in the early season during and after blossom period to control scab disease for in apple and pears. These diseases are of high importance and affect growers in all pome fruit growing states and can cause high yield loss to these crops (Gauthier, 2018). Trees are most susceptible during bloom because fungal spores can enter flowers and cause blossom shedding or severe infection of developing fruit (Pscheidt and Ocamb, 2022). Diseased fruit develop brown or black lesions, eventually creating cracks in the fruit skin which can allow other fruit-rotting pathogens to enter the fruit and proliferate within (Pscheidt and Ocamb, 2022). Yield or quality losses can occur if scab is not managed effectively; fruits with visible scab lesions are unfit for the fresh fruit market. Apple scab disease has been documented to cause up to 70 percent yield losses (Peter, 2023). Pear scab causes blemishes on fruits that cannot be sold in fresh fruit market and are processed for juice or culled resulting in losses (Pscheidt and Ocamb, 2022).

Pscheidt and Ocamb (2022) recommend several single-site and multi-site fungicides for scab management and recommend that growers adopt fungicide resistance management measures, including alternating or tank-mixing fungicides from different FRAC groups and limiting the number of fungicide applications from any particular single-site group to two or fewer per year. Resistance management is important in pome fruit scab management, as strains of the pathogen (*Venturia* spp.) with resistance to multiple single site MoA fungicides have been reported in the Pacific Northwest (Pscheidt and Ocamb, 2022). No resistance has been reported in pathogen to mancozeb.

Multi-site fungicides that are registered and recommended for control of scab diseases in pome fruit include mancozeb, captan (FRAC M04; apple only), ferbam and ziram (FRAC M03), sulfur, lime sulfur (FRAC M02), and copper (Pscheidt and Ocamb, 2022; Ayer and Cox, 2021; Robinson and Hoying, 2010). Mancozeb and captan are dominantly used in controlling apple scab disease and both are already used in apple for season long disease control programs (Kynetec, 2022a, 2022b). Ferbam and ziram are under registration review and the Agency has proposed their cancelation on apple and pears (EPA, 2024a; EPA, 2024b). For scab control copper and lime sulfur are recommended for application as a delayed dormant (prior to bloom time) spray to control scab disease, when disease pressure is low (Pscheidt and Ocamb, 2022). It is not advisable to apply copper or sulfur products later in the growing season due to the potential phytotoxicity causing fruit blemishes (Adaskaveg *et al*., 2022; Pscheidt and Ocamb, 2022). Mancozeb is an important fungicide for scab disease control due to application timing limitations for copper, sulfur, and lime sulfur.

Mancozeb and captan have comparable efficacy in controlling apple scab (Adaskaveg *et al*., 2022). Grower survey data indicates that in some states (e.g. New York) at least some growers during the 2017-2021 period, may already utilize all available applications of both captan and mancozeb in their season long disease control program (Kynetec, 2021a). Captan is currently undergoing registration review and may be subject to a reduced single application rate, however, BEAD previously found that most captan acres about 87% of acres treated) are treated at or below the newly proposed rate maximum single application rate (Chen et al., 2022; EPA, 2024c). If utilizing the maximum single application rate for scab in apples, growers are able to make four applications of mancozeb and ten applications of captan considering the newly proposed single application rate of 3 lb AI/acre (up from eight applications which were allowed under the 4 lb AI/acre single application rate).

On pears, captan is not registered for foliar use, meaning pear growers have fewer efficacious multi-site alternative fungicides than apple to control fungal pests including scab disease. If unable to use mancozeb, pear growers have to plan scab control programs using available multisite MoA alternatives (copper, sulfur, and/or lime sulfur). Copper, sulfur, and/or lime sulfur can be phytotoxic and single-site alternatives fungicides are prone to resistance development in fungal diseases including scab (Adaskaveg *et al*., 2022; Pscheidt and Ocamb, 2022; Jamar *et al*., 2017). Without mancozeb, the growers may have to incorporate more single site fungicides into their season long disease control program which would be more costly because fungicides cost more on a per acre basis and could compromise resistance management (Kynetec, 2021a).

A secondary benefit of mancozeb use in pear is that it suppresses pear psylla nymph, an insect pest. Mancozeb can be applied at a single application rate of up to 6 lb AI/acre for suppression of this pest in Oregon and Washington (OSU, 2018; Burts, 1983).

BEAD finds that mancozeb provides high benefits to apple and pear growers. In the absence of mancozeb, growers would have to rely more heavily on single site fungicides because of limits on the number of allowable applications of captan in apple and the lack of multisite option that can be used after bloom in pear. This would compromise growers' ability to manage resistance to single site fungicides.

Mango

In 2022, mango was grown on approximately 3,100 acres in the U.S. (USDA NASS, 2024a). Approximately 78% of U.S. grown mango bearing acres occurred in Florida in 2022 with the remaining production occuring in Hawaii, California, and Texas (USDA NASS, 2024a).

Mango anthracnose (*Colletotrichum gloeosporoides*) is a very important disease that can infect flowers and result in young fruit drop-off (Nishijima, 1993; Nelson, 2008; USDA OPMP, 2024). In harvested fruits, anthracnose disease causes dark lesions and infected fruits can be unmarketable. Anthracnose disease can cause yield losses up to 100 percent if disease is not controlled (Dofuor et al., 2023). Other diseases appear to be less problematic in mango (USDA OPMP, 2024).

Multiple fungicides with a multisite MoA (chlorothalonil, copper, mancozeb) are registered for use in mango and can be used to control fungal diseases (such as anthracnose, scab) (USDA IPM, 2014). In Hawaii, mancozeb and copper-based fungicides have been reported to be effective in controlling anthracnose disease of mango (Nishijima, 1993). In Florida, copper fungicides are recommended and are reported to be effective in controlling anthracnose disease from flowering to fruit development (Rezazadeh, 2023). Mancozeb has been reported to be more effective than copper in controlling anthracnose disease in mangoes (Arauz, 2000; McMillan, Jr., 1984). USDA OPMP (2024) commented on chlorothalonil PID that chlorothalonil is heavily used in mangoes to control anthracnose disease. USDA also commented that reducing current annual maximum of chlorothalonil would limit growers to a single application and would jeopardize season-long control of anthracnose disease in mangoes. BEAD does not have reliable information on number of applications of each multisite fungicide necessary to maintain season long disease control program in mango. If the proposed restriction on chlorothalonil is implemented, then chlorothalonil can be applied once per year. If mancozeb is not available, given the proposed limits on chlorothalonil growers would have to rely on copper and potentially more applications on single site fungicides for anthracnose disease control. BEAD finds moderate benefits of mancozeb use in mango because managing disease resistance to single site fungicides may be more difficult.

Papaya

In 2022, Papaya was grown on approximately 880 acres in the U.S. (USDA NASS, 2024a). Approximately 84% and 15% of U.S. papaya acres were grown in Hawaii and Florida, respectively, in 2022 with minor production reported California and Texas (USDA NASS, 2024a).

In addition to mancozeb, chlorothalonil and copper are also multisite fungicides registered for use on papaya. Several fungal diseases affect papayas in the U.S., and among these diseases, anthracnose, black spot, damping-off of seedlings, Phytophthora stem and fruit rot, and powdery mildew are important (Hine *et al*., 1965). Anthracnose disease causes lesions on fruits and fruit rot, and infected fruits are unmarketable. Phytophthora causes fruit and tree stem rot (Hine *et al*., 1965). BEAD reached out to USDA OPMP (2022) for information on mancozeb use in papaya. USDA OPMP (2022) informed the Agency that in Hawaii, papaya growers apply mancozeb (2.0 to 2.5 pounds AI /100-gals water/acre) via hand spray gun every 14 days (during wet weather conditions) on papaya tree stems to control fruit rots (anthracnose) and Phytophthora fruit and stem rot that can result in high crop losses.

Copper may be used to control Phytophthora fruit and stem rot but in general, copper is less effective than mancozeb in controlling Phytophthora disease in papaya (Vawdrey *et al.*, 2015). BEAD finds that mancozeb provides high benefits to papaya growers because without mancozeb the growers may have to rely on less effective copper alternatives to control fruit rots (anthracnose) and Phytophthora fruit and tree stem rot that may lead to yield and quality loss of harvested crops.

Grapes

Between 2017-2021, an average of approximately 1,013,600 bearing grapes acres were grown in the US annually (USDA NASS, 2024b). California is the largest producer of grapes in U.S.; this state produced nearly 1 million tons of grapes for the fresh market and 5.3 million tons of grapes for processing (mostly for raisins and wine). Also in the west/northwest, Washington and Oregon combined produced 457,000 tons of grapes for processing (wine and juice). In the midwest, upper midwest and east, northeast regions most grape production was for processing but a small portion went to fresh market (Table 3). In both of these regions about 70% and 30% of the processing production (tons) were processed for juice and wine respectively. Most of Texas production (tons) went for processing wine.

Table 3. Annual average grape production by region, 2017-2021[1, 2]

Region	Acres bearing	Fresh market production (thousands of tons) [3]	Processing production (thousands of tons) [4]
West (California only)	844,000	999	5,317
Pacific Northwest	96,800	0	457
Midwest, Upper Midwest	15,700	2	259
East, Northeast	52,500	3	291
South (Texas only)	4,600	<1	11
US Total	1,013,600	1,004	6,336

Source: USDA NASS, 2024b

[1] Pacific Northwest is Washington and Oregon; Midwest, Upper Midwest is Michigan, Ohio, Missouri; East, Northeast is New York, Pennsylvania, Virginia, North Carolina

[2] For some states, only one year of data (2017) was available so production values represent only that year.

[3] Primarily table grapes.

[4] Wine, juice, jams and jellies and includes raisins in California.

Usage data from California indicates that mancozeb was rarely applied to wine, table, and raisin grapes from 2017-2021, as the average percent of crop treated for each of these grape varieties was ≤2.5 PCT (Table 1). In Washington in 2017 and 2018, no mancozeb usage was reported (Kynetec, 2021a). Due to this low PCT in California and no usage reported in Washington, BEAD expects that the benefits of mancozeb in California and the Pacific Northwest grape production are low.

Outside of California and Washington, the only other available usage data provided by USDA NASS is from New York which ranks third in grape production with about three percent of all grape acreage. The most recent available year of quantitative usage data from USDA NASS

(2023) for New York, indicate that about 85 percent of the grape crop was treated with mancozeb, amounting to approximately 246,000 lbs AI applied in 2017 (USDA NASS, 2023). An average of about three applications of mancozeb were reportedly used on New York grapes (USDA NASS, 2023). Mancozeb may also be utilized by grapes growers in the midwest, upper midwest or other eastern states because of similar climate conditions. Overall, based on available usage information, grapes growers in eastern states rely heavily on mancozeb for disease control.

Mancozeb is labeled for controlling multiple diseases in grapes including black rot, Phomopsis disease, downy mildew, and bunch rot (also known as Botrytis bunch rot). These pests are of higher importance in New York and other states east of the Rocky Mountains than in the west due to the favorable weather conditions (frequent rain and high humidity).

Black rot disease (caused by *Guignardia bidwellii*) affects all young green tissues of the vine (Wilcox, 2003). Small, brown circular lesions develop on infected leaves and elongated black lesions on the petiole that may eventually girdle and result in leaves wilting (Wilcox, 2003). Shoot infection results in large black elliptical lesions and these lesions may contribute to breakage of shoots by wind, or in severe cases, may girdle and kill young shoots (Wilcox, 2003; Ellis, 2008). Phomopsis disease (caused by *Phomopsis viticola*) is common in eastern grape growing areas (Smith *et al*., 2015a). The disease causes lesion on grapevine shoots and leaves. The lesions can be dark brown to black. Severely affected shoots are prone to wind breakage and severely affected leaves are distorted and may drop prematurely (Smith *et al*., 2015a; Myers, 2006). Downy mildew (caused by *Plasmopara viticola*) is a serious disease of grapes that can cause severe crop losses if not controlled. The fungus attacks all green parts of the vines, the diseased plant part turns brown and die. The young berries are highly susceptible. They appear grayish when infected and become covered with a downy felt of fungus sporulation. Infected berries remain firm, compared to ripening healthy berries, and drop easily (Smith *et al*., 2015b; Ellis, 2016).

Extension sources cite the importance of early season control of grape diseases (black rot, Phomopsis disease and downy mildew) (Hartman, 2024). Mancozeb is highly effective in controlling these three diseases (Gauthier, 2019). Other multisite fungicides registered for use in grapes include captan, copper, and ziram. However, the Agency recently proposed cancellation of ziram (EPA, 2024a). Copper has poor efficacy in controlling these three diseases (Gauthier, 2019). Captan is effective in controlling Phomopsis and downy mildew but has poor efficacy in controlling black rot disease (Gauthier, 2019; Gold, 2021). Therefore, if mancozeb were unavailable, growers would have to rely primarily on single site fungicides (e.g., myclobutanil) for effective control of black rot increasing the risk of resistance. Further, single site fungicides are generally more expensive than mancozeb (Kynetec, 2021a), resulting in additional costs of fungicide treatment.

BEAD concludes that mancozeb provides high benefits to eastern states grape growers because it is the only multisite fungicide that provides control of black rot and for its role in resistance management and season long disease control in grapes. BEAD also concludes that mancozeb provides control at a lower cost than single site fungicides which are generally more expensive than multisite fungicides.

Cranberry

Cranberry growing regions of the U.S. include the northeast (Massachusetts and New Jersey), midwest (Wisconsin), and pacific northwest (Oregon and Washington) (USDA NASS, 2024a). In 2022, approximately 40,000 acres of bearing cranberries were grown in the US (USDA NASS, 2024a).

Fruit rot is a major disease in cranberry and can cause 15 to 30 percent yield losses without the use of fungicides (Murray *et al*., 2018). Fruit rot disease can be caused by multiple fungi such as *Coleophoma empetri, Colletotrichum acutatum, Colletotrichum gloeosporioides Fusicoccum putrefaciens Monilinia oxycocci1 Phomopsis vaccinii Phyllosticta vaccinii Physalospora vaccinii* in cranberry (Oudemans, 2011). To control cranberry fruit rot, mancozeb and other multisite fungicides (such as chlorothalonil, ferbam) are recommended as post bloom applications at an interval of 10-14 days (Oudemans, 2011; NE IPM, 2024). Single site MoA fungicides are generally not recommended for control because they are very selective in their disease control spectrum and have poor efficacy in controlling fruit rot (NE IPM, 2024). Mancozeb and chlorothalonil are very effective in controlling fruit rot under moderate to high disease pressure whereas ferbam and copper have lower efficacy than mancozeb and chlorothalonil in controlling fruit rot (Oudemans, 2011). Similarly, Murray *et al*., (2018), reported excellent, good to excellent, and good efficacy of chlorothalonil, mancozeb and ferbam, respectively in controlling cranberry fruit rot. However, ferbam is under registration review and the Agency has proposed its cancelation on cranberry (EPA, 2024b). The Agency has also proposed to reduce the total annual maximum application rate for chlorothalonil, which effectively limits growers to two applications per year (EPA, 2023). The Cranberry Institute *et al.* (2024) relayed in a public comment on the chlorothalonil PID that most growers can manage fruit rot with only two applications of chlorothalonil, but growers who face higher disease pressure may require three applications.

BEAD finds that mancozeb provide high benefits to cranberry growers in areas of the northeast where high fruit rot pest pressure may be higher than other cranberry producing regions and mancozeb may be needed in addition to two chlorothalonil applications for season-long disease control.

Impacts of Potential Mitigation to Occupational Risks

Additional Personal Protective Equipment for Handler Exposure – APF10 Respirator and Double Layer Gloves

EPA may require additional Personal Protective Equipment (PPE) for mixer/loaders preparing for an application of mancozeb. Most current mancozeb product labels require handlers to wear single-layer baseline attire (long-sleeved shirt, long pants, shoes, and socks), but do not require additional personal protective equipment (PPE). Requiring double-layer coveralls and gloves for mancozeb mixers, loaders, and applicators is not anticipated to have a great impact on users of mancozeb since use of a PPE (e.g., wearing double layers when applying pesticides) can reduce productivity of workers because of the physiological stress when working in high temperatures and/or humid conditions (O'Brien *et al.,* 2011). Workers may need to take more frequent breaks in certain situations than if extra PPE were not required. Individuals will respond differently depending on many factors, such as fitness level, hydration, acclimatization, etc. More frequent breaks increase the time to perform the same task and decrease labor productivity and increases costs.

Requiring the use of a respirator may impose a cost on users for the respirator and fit test unless they already use a respirator for other chemicals. Respirator costs are extremely variable depending upon the protection level desired, disposability, comfort, and the kinds of vapors and particulates being filtered. Assigned Protection Factor 10 (APF10) respirators include N95 masks which are relatively inexpensive. Under the Worker Protection Standard, users of respirators are also required to have a fit test done annually; BEAD found the cost of a respirator fit test to be about $350 per applicator per year; this includes fees and the time required to obtain the test (Smearman and Berwald, 2024). Alternatively, growers could hire a commercial applicator or use an alternative that does not require a respirator although, as described above, use of an alternative may have substantial impacts. In addition to potential monetary costs of respirators, the use of a respirator can reduce productivity of workers wearing a respirator, which could increase the time required to mix and load tanks, which could increase costs. Per Smearman and Berwald (2024), there may be differences as to who pays these costs.

Closed loading for Mixers and Loaders Utilizing Certain Mancozeb Formulations

The Agency is considering requiring a closed pesticide delivery system for mixing and loading when preparing dry flowable (DF) and wettable powder (WP) formulations of mancozeb. This requirement may only be required for growers preparing for aerial or chemigation applications because these are the application methods for which risks were identified. Most applications of mancozeb in orchard crops were made using DF formulation (Kynetec, 2022a). However, most mancozeb applications were made via airblast in the case of orchard crops however some acres (<1% total acres treated) were reportedly treated aerially in almond, walnut, apples and pears over the period 2017-2021 (Kynetec, 2022a). BEAD anticipates that the majority of mancozeb applications made in grapes are made via airblast equipment as this was noted by USDA OPMP to be the predominant application method in grapes (USDA OPMP, 2021). Therefore, most growers may be unaffected by the closed pesticide delivery system requirement (Kynetec, 2022a).

Enclosed Cab for Airblast Applications of Mancozeb

EPA is considering the requirement of an enclosed cab for all airblast applications of mancozeb. Applicators who do not already have the appropriate equipment would either have to purchase the equipment, retrofit their current machinery, or hire a commercial firm with the equipment to make mancozeb applications. All of these options increase the cost of using mancozeb unless applicators already own equipment with an enclosed cab. This will affect smaller farmers more greatly than larger farmers because they have fewer acres over which to spread the fixed cost.

The Agency recognizes that the enclosed cab requirement for airblast applications has also been proposed for captan, which is another fungicide that is used and beneficial in apples which is also assessed in this memo (EPA, 2024c). This is relevant because apple growers for example may already be subject to this requirement if also using captan. While the Agency received has previously received comments that tight orchard spacing preclude the use of an enclosed cab in some orchards, BEAD finds that airblast equipment would generally be as wide or wider and as high as a tractor with enclosed cabs (Chandgoyal *et al.*, 2024). Therefore, the Agency anticipates that spacing between crop rows must allow for the passage of airblast equipment and therefore an enclosed cab should also be able to pass through.

Disallowing Use of Mechanically Pressurized Handguns

The Agency is considering prohibiting the use of mechanically pressurized handguns when making mancozeb applications. USDA OPMP noted that Hawaii papaya growers utilize mechanically pressurized handguns to apply mancozeb (USDA OPMP 2022). Otherwise mechanically pressurized handguns are only anticipated to be used in experimental orchard trials in research and extension centers and so disallowing their use should not impact growers of any other crop analyzed in this memo (USDA OPMP 2022).

Cancellation of Mancozeb Use in Grapes

Post application risks of mancozeb use were identified for tying/training, hand harvesting and leaf pulling up to 45 days and for girdling and turning up to 72 days after a mancozeb application in grapes (considering the maximum single application rate of 3.2 lb AI/acre). Imposing a REI of such length would preclude the use of mancozeb because it would impede growers' ability to conduct other production activities. A lower single application rate (e.g., 2.5 lb AI/acre) would still result in risks that could not be addressed with a feasible REI.

With the loss of mancozeb in grape production, BEAD anticipates that at a minimum, grape growers east of the Rocky Mountains will experience an increased cost of pest control as growers will need to integrate more single site fungicides. The growers would have to rely primarily on captan to control Phomopsis disease and downy mildew and single site fungicides (e.g., myclobutanil) for effective control of black rot increasing the risk of resistance. Further, single site fungicides are generally more expensive than mancozeb (Kynetec, 2021a), resulting in additional costs of fungicide treatment.

Increased Re-entry Intervals

To reduce post application exposure to mancozeb in production, EPA is considering extending the restricted entry interval for hand labor activities after a mancozeb application has been applied. Longer restricted entry intervals reduce exposure workers handlers by preventing entry into a treated area for a set period. An extended REI can be disruptive to normal grower operations by preventing important tasks from being performed in the treated area in a timely manner.

Almonds and Walnut

For almonds and walnuts, the current REI is 24 hours. EPA calculates that the level of concern is exceeded up to four days after application. In walnuts, in-season activities include pruning and scouting (UC David WIFSS, 2016a). BEAD anticipates that a 4-day will not significantly impact these activities as growers can likely plan such activities such that they occur before a mancozeb application is applied. Similarly, there is likely to be little impact in almonds; growers have multiple options for disease control if the REI were to conflict with any activities.

The Worker Protection Standard and REI longer than 48 hours requires warning signs to be posted, which will be an additional cost for walnut and any almond growers who rely on use of mancozeb in their orchards.

Apples and Pears

The Agency identified occupational post application risks of concerns for workers entering fields to scout, hand prune and train of up to 4 days and to workers thinning fruit beyond 35 days in pome fruit. To address the risks associated with thinning, the Agency may consider requiring an REI of at least 35 days for hand-thinning or a prohibition of hand-thinning. In addition, the Agency is considering a 4-day REI for all other activities. Hand harvest was also identified to be an activity of concern when utilizing mancozeb in apples and pears. However, although a risk was modeled mancozeb's already require a 77-day pre-harvest interval (PHI) for apple and pears; therefore, mancozeb is only utilized as an early season tool in these crops and workers would not be exposed to mancozeb during harvest.

BEAD first focuses on the impacts of a potential 35+ day REI on hand thinning or a prohibiting hand thinning if utilizing mancozeb. As mentioned in the benefits section above, mancozeb is applied in the early season during and near the blossom period for apple and pears, so near the time that hand thinning would potentially occur. USDA (2021) has reported that "proper apple spacing and crop load management is critically important, not just for fruit quality, but also return-bloom the following season." However, in most commercial production, chemical thinning (not hand thinning) is the most common practice for thinning fruit in apples and pears. There are some high-value fresh market varieties that are thinned by hand because they are very sensitive to chemical agents and overthinning can occur. Apple growers who require hand thinning can use captan in the early season because the REI for hand thinning in captan is 6 days per the recent Amended Proposed Interim Decision for captan (EPA, 2024c). Pear growers managing high-value varieties could apply single site fungicides in place of mancozeb but this could compromise disease control and resistance management.

A 4-day REI for all other activities in apples and pears is not likely to impact growers because growers can plan any necessary activities (e.g., pruning) so that they occur before or 4 days after an application of mancozeb is made.

Mango and Papaya

The Agency identified occupational post application risks of concerns for workers entering mango and papaya fields to hand harvest fruit of up to 4 days and to hand thin fruit up to 34 days after a mancozeb treatment. To address these risks, the Agency may consider requiring an REI of up to 34-day REI for hand-thinning fruit or a prohibition of hand thinning when utilizing mancozeb in mango and papaya production. The Agency may also consider a 4-day REI for all other activities. Currently, mancozeb products have a one-day REI for mango and papaya although some products have an REI of 48 hours.

BEAD does not anticipate hand thinning to be a common practice however, in some mango varieties and in papaya hand thinning may be needed (Blare *et al.*, 2022; Constantanides *et al*., 2008). A 34-day REI for hand thinning is expected to be manageable for mango and papaya growers because other multisite fungicides (e.g., chlorothalonil and copper) are available for early season applications while mancozeb could be applied after hand thinning. Thus, growers could maintain their resistance management program.

Other in-season activities that occur in tropical and sub-tropical fruit like mango and papaya include pruning and training (Wasielewski *et al*., 2023). BEAD anticipates that a 4-day will not significantly impact these activities as growers can likely plan such activities such that they occur before a mancozeb application is applied. Unlike other crops, mancozeb labels the PHI for mango and papaya is zero days. Therefore, if hand harvesting is utilized (UC Davis WIFSS, 2016b), growers would also need to plan any hand harvest activities such that they occur 4 days or more after a mancozeb application is made.

Cranberry

For cranberry, EPA may propose a 4-day REI, and increase from the current 24-hour REI. Impacts are expected to be negligible to low, as activities would not be disrupted for very long. The longer REI will require posting of warning signs at additional expense.

Impacts of Potential Spray Drift Mitigation (Bystander and Ecological Risks)

To mitigate spray drift risk to bystanders (which will also improve any spray drift risks for non-target species), EPA is considering requiring spray drift mitigation. Buffers offer a physical separation between the treated area and an area where bystanders and/or non-target species may be located. Some of the measures used to reduce drift include changing droplet size, lowering release height, and restricting applications based on windspeed.

Buffers

BEAD considers the impacts of requiring buffers ranging from 25 to 100-feet for both groundboom and aerial applications. In this section, BEAD describes the impacts on mancozeb users of requiring buffers ranging from 25 to 100-feet, where larger buffers could be associated with aerial applications.

For some growers, even a 25-foot buffer may have substantive impacts. Growers who would be required to implement a buffer have three main options, all of which result in the loss of mancozeb as a control method in the buffer area: 1) replace mancozeb with an alternative control method for treatment of the entire field, 2) replace mancozeb with an alternative control method in just the buffer area while treating the interior field with mancozeb, or 3) use mancozeb to treat only the interior of the field and leave the buffer areas untreated. The second option listed would likely necessitate extra applications to trips through the field. Extra trips through a field imposes a burden beyond just the time it takes a grower to make the extra trip – growers must clean equipment before switching to another chemical; also environmental factors (wind, rain) and equipment availability, may further limit the feasibility of making separate applications to buffers. Beyond the increased application costs, growers would also incur any impacts from using alternatives, as with the first option. Under the third option, yield or quality losses would be highly likely since if the buffer area is left completely untreated. In some situations, losses may be large enough that it is no longer worth cultivating the buffer and growers remove the land from production.

Buffers can affect a substantial portion of a field, especially when fields are small as may be the case for the crops discussed in this memo. To characterize the effect that buffers may have on growers, BEAD shows how different sizes of no-spray buffers can impact growers who want to use mancozeb on different sized fields (Table 4). To illustrate the effect of a buffer, consider a rectangular field with length equal to twice its width, with the buffer on the long side of the field. In this scenario, the field is immediately adjacent to the sensitive area. A 25-foot buffer results in the loss of 2% of a 50-acre field, but 4% of a 10-acre field. A 100-foot buffer results in the loss of 10% of the 50-acre field, and 21% of a 10-acre field. If the buffer were to fall on the short side, the affected area would be substantially less. Irregularly shaped fields could be affected substantially more. In situations where the field to be treated is not immediately adjacent to the protected area, the part of the field affected by the spray buffers is smaller/narrower than if the field edge is immediately next to the habitat. EPA has limited information on field size, however, the following provides a range of farm size for orchard/vineyards to provide context. For example, the 2022 Census reports average farm size for farms in fruit and tree nut farming (NAICS 1113) is 149 acres and 83% of those farms have less than 50 acres in production.

Table 4. Illustration of percent of fields of various sizes lost to in-field buffers of various sizes.[1]

Field Size (Acres)	**1**	**10**	**50**	**100**
Buffer Size	**Percent of Field Impacted by Buffer**			
25 Feet	12%	4%	2%	1%
50 Feet	34%	11%	5%	3%
100 Feet	68%	21%	10%	7%

[1] Calculations based on a rectangular field with length equal to twice its width, with the in-field buffer on the long side of the field.

Impacts of buffers can be reduced if buffers are made contingent on wind direction. As such, EPA may also require smaller buffers when using drift reduction tools for applications made by ground boom, such as hooded sprayers or windbreaks/shelterbelts. This would reduce the burden of the mitigation by giving growers additional flexibility in applying mancozeb; however, growers may incur some up-front costs to use these tools. The burden of purchasing a hooded sprayer or installing windbreaks/shelterbelts may be greater for smaller operations, which may face higher per-acre costs for equipment and potentially higher financing costs.

Medium or Coarse Droplet Size

The Agency is considering requiring a medium or coarse spray droplet size for all applications of mancozeb because coarser droplets have been demonstrated to decrease off-target spray drift and, therefore, may reduce potential exposures to non-target species. However, coverage tends to decline with larger droplets because the droplets hold together rather than spread out over the foliage which could result in a potential reduction in efficacy. As a contact fungicide, mancozeb's efficacy is dependent on coverage. Generally, fungicides are applied using fine to medium droplets (Grisso *et al*., 2019). Because of this, BEAD anticipates that growers can use a medium droplet size for mancozeb applications without experiencing reductions in efficacy. If EPA were to require coarse droplets in the case of mancozeb, growers may experience decreased efficacy. Growers could compensate by increasing application rates, if allowed by the label, making more fungicide applications, or using alternative products, which could increase production costs or lead to yield loss. Mandating a larger droplet size could also limit growers' ability to tank mix multiple chemicals if partner chemicals require smaller droplet sizes to be efficacious. This could result in growers making sequential applications, increasing labor and fuel costs. EPA encourages comments on any potential impacts to growers from specifying a mandatory minimum droplet size on product labels.

Windspeed Restriction

Currently some mancozeb labels require that an applicator not make an application when the windspeed is greater than 15 mph. To mitigate spray drift risk, EPA is considering prohibiting groundboom and aerial applications when the wind speed is greater than 10 mph. Wind conditions vary across the U.S. and wind speed restrictions could prevent timely applications of mancozeb.

Mandatory wind speed restrictions complicate pest and crop management by reducing the available time to make applications and make it more likely that a grower may need to alter pest control plans. Changing plans may result in additional costs. If applications are not made in a timely manner, pest control could decline, potentially leading to additional applications, which may result in yield losses, and/or accelerate the development of resistance. In the case of fungicides in particular, disease prevention and early control are critically important because irreversible crop damage can occur very quickly if a disease goes uncontrolled.

In conclusion, a 10-mph wind speed maximum may prevent, in some cases, the timely application of chemical controls, resulting in reduced yield and quality of the crop and increase costs to growers. The Agency welcomes comments from growers and applicators about their fungicide application practices considering wind speeds.

Impacts of Additional Potential Mitigation for Ecological Mitigation

The Agency is also considering other risk mitigation measures to reduce the risks of mancozeb to non-target organisms by reducing pesticide spray drift and runoff or avoiding exposure. The impacts of potential spray drift mitigation was discussed in the previous section.

Aqueous runoff mitigation

48-hour rainfall restriction

BEAD expects a 48-hour restriction on applications prior to rainfall can be highly impactful to users of mancozeb, as periods of wet weather are when plants are most vulnerable to foliar diseases. Coating plants with a protective fungicide such as mancozeb prior to rain events helps to prevent the initiation infection and spread of disease; for this reason, fungicide applications are commonly recommended to be applied before a rainfall event (Egel, 2021; Quesada-Ocampo, 2023). Protectant fungicides such as mancozeb work best when applied during sunny and dry conditions (Cato, 2020; Schilder, 2010). When allowed ample time to dry (at least a few hours), new formulations of protectants can continue to provide protection during and after rain. In general, university agricultural extension recommendations advise that growers apply contact fungicides at least a few hours or up to 24 hours before rain (Cato, 2020; Paul, 2016; Schilder, 2010; Warmund, 2018). However, to restrict mancozeb applications 48 hours before a rain event limits users' flexibility in using mancozeb to protect crops against fungal diseases during vulnerable wet weather events, which could lead to suboptimal disease control and/or prompt users to switch to an alternative fungicide. In the case of mancozeb, growers may have no other synthetic multisite fungicide options available to turn to during these periods; this may be the case when mancozeb is already being utilized for other applications over the growing season.

The likelihood of a grower being impacted by a 48-hour restriction on applications prior to rainfall would vary based on the time of year when mancozeb (which will vary by crop as some crops rely on mancozeb applications throughout the growing season) is being applied and the prevailing frequency and intensity of rainfall in the area.

No applications during rain

To reduce the potential for runoff, the Agency is considering prohibiting mancozeb applications during rain. The Agency does not anticipate that a restriction which prohibits mancozeb applications while it is raining will affect applicators. While fungicide applications may be made prior to a rainfall event, applicators would not apply during a rainfall event, as this would not be desirable for the product staying in place and preventing disease.

Impacts of requiring that growers obtain and follow Bulletins Live! Two labelling

EPA may require that growers obtain and follow Bulletins Live! Two (BLT) ahead of an application of mancozeb. This internet-based system will inform the user of any additional requirements in their specific geographic area. Because some of the mitigation measures needed to protect threatened and endangered species (referred to as listed species) may be applicable only in particular geographic regions where listed species occur, and/or because listed species may require different mitigations for the use of mancozeb to protect them from exposure, a physical label that contains all the mitigation information would be many pages long and difficult to use. The complexity of a paper label would likely be compounded by the future changes to the listed species and their ranges. To simplify this process, EPA will provide information on what mitigations are required for a particular location in Bulletins Live! Two (BLT).

The BLT system has been in place for many years but the requirement to access BLT before using a pesticide is relatively new for many pesticide products. As discussed in the ESA Workplan Update issued by the Agency in November 2022, the requirement to access BLT will eventually apply to most pesticides (EPA, 2022). Therefore, over time and with wider implementation, BLT will become a tool that growers are familiar with, and consulting BLT ahead of a pesticide application will become routinely integrated into a user's application process. Growers must obtain the relevant bulletin and check for additional mitigation no earlier than six months prior to the intended application.

A recent USDA (2023) report on farm computer usage and ownership reported that 85 percent of farms have internet access, a number that is up from 73 percent in 2017, and a similar proportion of farms own smart phones and/or computers (USDA, 2019 and 2023). However, fewer farms reported using the internet to conduct business. Therefore, BLT will be accessible for most growers. However, for growers who do not have internet, accessing BLT requires additional steps who must rather seek other means to access Bulletins relevant to their farm or field. As mentioned earlier, growers not accustomed to accessing BLT as a part of their regular farm business, especially those not accustomed to using online tools to conduct business could face a learning curve but with time and as users become acquainted with this system, this burden will diminish.

However, some BLT requirements may be more stringent in a Pesticide Use Limitation Area than those described in this memo and could even prohibit use in a designated area. If land use practices (additional mitigation measures) are required, growers may need substantial time (potentially more than six months) and careful planning to implement them. Bulletins could change over time, which adds additional complexity and uncertainty for operating a farm business.

Conclusion

BEAD concludes that mancozeb provides high benefits in apple and pear production due to its role in managing resistance to other fungicides. Without mancozeb, growers would apply more single-site fungicides with greater frequency to obtain season-long control of scab, increasing the likelihood that resistance would develop. Benefits are also high in walnut and papaya where mancozeb is used for control of walnut blight and Phytophthora fruit and stem rot in papaya. Copper is a less effective alternative so in the absence of mancozeb growers could incur yield or quality losses. BEAD also finds high benefits to the use of mancozeb in grape production in eastern states where conditions are conducive to black rot as captan is less effective and sole reliance on single-site fungicides for control would likely result in resistance developing in black rot. There are also high benefits to the use of mancozeb in cranberry production in the Northeast. In cranberry, one application of mancozeb per year is important for growers because under high disease pressure of fruit rot disease the growers need a minimum of three applications of multisite fungicides (chlorothalonil and mancozeb) and chlorothalonil can only be applied two times due to new proposed new annual limit.

BEAD finds moderate benefits of mancozeb use in mango. Without mancozeb, growers may have to make more frequent applications of single-site fungicides at some increase in cost but can likely maintain resistance management programs with the use of chlorothalonil. Almonds were determined to have low benefits because multiple multisite fungicide alternatives are available to almond growers.

The EPA has identified risks to occupational handlers (mixers/loaders and applicators), bystanders, and to non-target organisms (ecological risks) associated with the use of mancozeb.

The Agency is considering reducing occupational handler worker exposure risks through:

- Requiring use of APF10 respirators and additional personal protection equipment (PPE) for mixers, loaders, and applicators when utilizing any mancozeb formulation. The primary burden is the cost to obtain an annual fit test of the APF10 respirator and the potential for heat stress on workers which can result in more frequent breaks and can increase the time and labor cost of utilizing mancozeb; and
- Closed loading system for mixers and loaders when utilizing dry flowable and wettable powder (DF and WP) formulations, which may entail the requirement that these formulations come in closed packaging that can be inserted into water in a pesticide delivery system and mixed with the container closed. This will increase packaging costs and may also require that applicators utilize equipment that can agitate or mix while the system is closed. Costs of mancozeb use will therefore increase if this requirement were to apply. While growers could opt to switch to utilizing a liquid formulation, it is currently may be double the cost of the DF formulation on a per acre basis; and

- Requirement to use an enclosed cab for airblast applications. This is anticipated to be costly for applicators who do not already have the appropriate equipment, particularly for growers operating fewer acres as they have fewer acres over which to spread the fixed cost of enclosed cab purchase or retrofitting upgrade. Alternatively, growers could hire a commercial firm with the equipment to make mancozeb applications however this would also increase grower costs; and
- Prohibiting use of mechanically pressurized handguns. Prohibiting mechanically pressurized handgun use for mancozeb is anticipated to have minimal impacts but may impact papaya growers in Hawaii who rely on this method of application of mancozeb to drench papaya tree trunks.

The Agency is considering addressing post-application worker exposure risks through:

- Cancelling use of mancozeb on grapes. If mancozeb is unavailable in grape, growers would have to rely on more single site fungicides to control black rot which would compromise resistance management of this disease.
- Extending the restricted entry interval (REI) by up to four days. A 4-day REI is not anticipated to be highly disruptive or impactful to current production practices in these crops. However, it would require that operators post warning signs, which could be an additional burden in time and labor.
- Prohibiting hand thinning in orchard crops. A prohibition on hand thinning is expected to impact only those apple and pear growers managing high-value varieties where hand thinning may be utilized; hand thinning is not anticipated to be a practice that is done in a commercial apple or pear production. A prohibition of hand thinning may be de-facto cancellation for papaya but is not anticipated to impact mango growers as hand thinning is not anticipated to be done in mango; and

The Agency is considering addressing bystander and ecological risks through:

- Spray drift mitigation (i.e., windspeed restrictions to 10 mph, increased droplet size, and buffers). Windspeed restrictions reduce grower flexibility when making a pesticide application. A medium droplet size is anticipated to be acceptable for growers utilizing mancozeb, but larger droplets could reduce coverage and efficacy. Buffers may mean that growers have to treat a portion of the field with different fungicides or leave the area untreated. If growers cannot apply mancozeb in buffer areas, then they would need to utilize another multisite fungicide, if applications are available, or utilize more single site fungicides which could compromise resistance management. The overall effect will vary depending on the size of the buffer and the size of the field affected.
- Prohibiting mancozeb applications 48-hours ahead of any projected rain event that is likely to result in runoff. This potential restriction on applications prior to rainfall to be highly impactful to users of mancozeb. Applications of mancozeb need to be made

ahead of a rain event because pathogens thrive in wet weather and pest pressure increases that has a potential to cause disease spread and ultimately high yield losses.

- Requiring that growers obtain and follow additional mitigations in Bulletins Live! Two ahead of pesticide application. Even though this web-based system has been in place for many years, the requirement that growers access and follow Bulletins is relatively new. Therefore, users may face a learning curve when becoming acquainted with the system. Moreover, growers may be subject to additional and potentially more stringent mitigation measures than those described in this memo which can require significant planning and may be costly to implement and maintain.

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