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(54) Title: COMPOSITIONS AND METHODS FOR REDUCING DRIFT ASSOCIATED WITH AGRICULTURAL PRODUCTS DELIVERED BY ROTARY ATOMIZERS

Veltyma

12,000 RPM disk speed

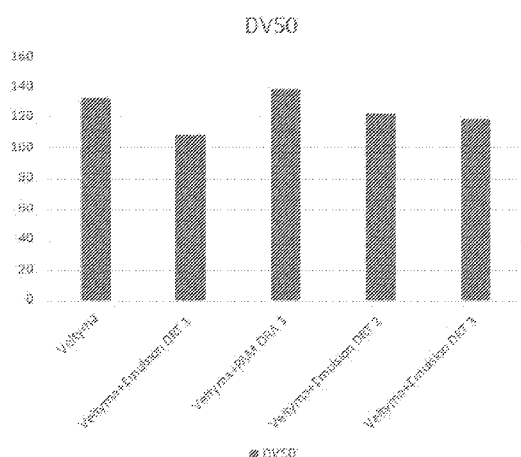


FIG. 1A

(57) Abstract: Provided herein are compositions comprising polyacrylamide and methods of use thereof for reducing drift associated with agricultural products delivered by rotary atomizers, including pesticides and/or crop protection enhancing adjuvants.

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COMPOSITIONS AND METHODS FOR REDUCING DRIFT ASSOCIATED WITH AGRICULTURAL PRODUCTS DELIVERED BY ROTARY ATOMIZERS

PRIORITY STATEMENT

5 This application claims priority to U.S. Provisional Application No. 63/516,708, filed July 31, 2023, the entire contents of which are incorporated herein by reference for all purposes.

FIELD

10 Provided herein are compositions and methods for reducing drift associated with agricultural products delivered by rotary atomizers. For example, provided herein are formulations for delivery of pesticides, including herbicides, insecticides, fungicides, and the like using unmanned aerial vehicle (UAV)-mounted rotary atomizers.

BACKGROUND

15 The agriculture industry has sprayed compositions onto agriculture for decades if not centuries to apply useful chemicals and compositions to agricultural crops. Specifically, it is well known to spray pesticides, including herbicides, insecticides, fungicides, and other like functional components, onto agricultural crops and/or soils to ward off and/or eliminate harmful insects, weeds, fungi and other like harmful elements. Fertilizers are also sprayed onto
20 agricultural crops and/or soils to supplement or replenish nutrients to crops and soils.

 Moreover, spray compositions are utilized to aid in Integrated Vegetation Management (IVM) and Integrated Pest management (IPM) applications for reduction of disease and pest vectors, in rights-of-way applications, in forestry applications, and in other like applications. The spraying of compositions has far-reaching applications beyond merely spraying on agricultural
25 crops.

 Droplet sizes of sprayed compositions are important to ensure that intended targets, such as agricultural crops and/or soils, are adequately treated. To ensure the adequate deposition of

functional compositions, sprays strike a balance between having droplet sizes that are small and light enough to be sprayed maximal distances, but heavy enough so that the droplets do not get carried away by wind or otherwise drift outside the intended application area. A need therefore exists for compositions that may be effectively sprayed onto intended target areas. Specifically, a need exists for compositions that form droplet sizes that are appropriately sized to maximize coverage of an intended target area.

Drift, as noted above, may cause compositions to be applied to unintended areas, such as environmentally sensitive areas, and may become pollutants leading to unintended effects on non-target organisms. For example, pesticides such as insecticides, herbicides, and fungicides may pose a hazard to unintended areas, and may disrupt ecosystems. Likewise, fertilizers may pose a risk if applied to unintended areas, also becoming pollutants. Drift of compositions to unintended areas or untargeted areas increases the cost of application as more composition must be used to cover intended areas than would otherwise be required. A need exists for compositions that may be easily controlled to spray onto intended areas while minimally affecting environmentally sensitive areas.

SUMMARY

In some aspects, provided herein are compositions. In some embodiments, provided herein are compositions comprising at least one of a pesticide and a crop protection enhancing adjuvant, and a polyacrylamide. In some embodiments, the composition is formulated such that it produces particles when released from a rotary atomizer. In some embodiments, the particles produced have an average diameter that is larger than the average diameter of particles produced by a composition lacking the polyacrylamide, and/or a driftable fraction of said particles is less than a driftable fraction of particles produced by a composition lacking the polyacrylamide. In some embodiments, the particles produced have an average diameter that is larger than the average diameter of particles produced by a composition lacking the polyacrylamide (e.g. a composition comprising the same pesticide and/or crop protection enhancing adjuvant, but not containing the polyacrylamide), and/or a driftable fraction of said particles is less than a driftable fraction of particles produced by an equivalent composition lacking the polyacrylamide.

In some embodiments, the polyacrylamide comprises a polyacrylamide microemulsion. In some embodiments, the polyacrylamide microemulsion is an inverse microemulsion. In some embodiments, the polyacrylamide microemulsion is a transparent/semitransparent inverse microlattice polyacrylamide. In some embodiments, the polyacrylamide microemulsion comprises polyacrylamide having less than 30 mole percent anionic charge. In some embodiments the polyacrylamide microemulsion comprises polyacrylamide having 0-22 mole percent anionic charge. In some embodiments the polyacrylamide microemulsion comprises polyacrylamide having 3-18 mole percent anionic charge. In some embodiments, the polyacrylamide microemulsion comprises polyacrylamide having 7-15 mole percent anionic charge. In some embodiments, the polyacrylamide microemulsion comprises polyacrylamide having 15-22 mole percent anionic charge.

In some embodiments, the crop protection enhancing adjuvant is selected from the group consisting of: crop oil concentrates, modified vegetable oils, drift retardants, soil or foliage penetrants, buffering agents, wetting agents, surfactants, nitrogen fertilizers, compatibility agents, defoamers, deposition agents, or combinations thereof. In some embodiments, the crop protection enhancing adjuvant is a lipophilic adjuvant. In some embodiments, the pesticide comprises an insecticide, an herbicide, a bactericide, a fungicide, a larvicide, a miticide, a nematocide, a plant growth regulator, or a combination thereof. In some embodiments, the pesticide comprises a lipophilic pesticide.

In some embodiments, the composition comprises 0.625-3.5% (v/v) pesticide. In some embodiments, the weight ratio of pesticide to polyacrylamide microemulsion is in a range of 99:1 to 90:10. In some embodiments, the weight ratio of pesticide to polyacrylamide microemulsion is 97:3. In some embodiments, the composition comprises a pesticide and 0.125-5% (v/v) of a combination of the polyacrylamide microemulsion and the crop protection enhancing adjuvant.

In some aspects, provided herein are methods of use for the compositions described herein. In some embodiments, provided herein is a method comprising contacting agricultural crops, turf and ornamental, or industrial vegetation management pests with a composition comprising at least one of a pesticide and a crop protection enhancing adjuvant, and a polyacrylamide. In some embodiments, contacting comprises spraying from a rotary atomizer.

In some embodiments, contacting comprises spraying from a rotary atomizer of a ground sprayer. In some embodiments, contacting comprises spraying from a rotary atomizer of an UAV or other aerial application equipment. In some embodiments, the UAV is a drone. In some embodiments, provided herein is a method comprising delivering a pesticide formulation to a plant or soil via a rotary atomizer, wherein said pesticide formulation comprises at least one pesticide, a crop protection enhancing adjuvant, and a polyacrylamide.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1A-1B show particle size analysis results using VeltymaTM fungicide tank mix with a high disk speed. FIG. 1A shows median droplet diameter and FIG. 1B shows the percentage of fine particles having a diameter of less than 141 microns with and without various adjuvants.

FIGS. 2A-2B show particle size analysis results using ShredderTM 2,4-D LV4 herbicide tank mix with a high disk speed. FIG. 2A shows median droplet diameter and FIG. 2B shows the percentage of fine particles having a diameter of less than 141 microns with and without various adjuvants.

FIG. 3 shows the average number of droplets across the spray swath at various offsets from the drone flight path after drone-based applications of water, emulsion with drift reducing technology (DRT), and emulsion with DRT and polyacrylamide (PAM).

FIG. 4 shows the percent coverage cross the spray swath at various offsets from the drone flight path after drone-based applications of water, emulsion DRT, and emulsion DRT + PAM.

FIG. 5A shows the number of droplets recovered and FIG. 5B shows the percent covered area under the drone spray swath after drone-based applications of water, emulsion DRT, and emulsion DRT + PAM.

FIG. 6A shows the number of droplets recovered and FIG. 6B shows the percent covered area averaged from 28 to 56 feet downwind from the drone flight path after drone-based applications of water, emulsion DRT, and emulsion DRT + PAM.

FIG. 7 shows the average number of droplets collected 56 feet downwind from the

drone flight path after drone-based applications of water, emulsion DRT, and emulsion DRT + PAM.

FIG. 8 shows results of a field spray deposition study conducted on bare ground. The percent coverage (AUDPS) is shown in the graph and results are quantified in the table below.

- 5 Oil-emulsion adjuvants both resulted in a lower spray coverage within the swath vs. water alone. In contrast, the oil-emulsion + PAM adjuvant (PAM DRA2) resulted in greater spray coverage within the swath vs. water alone.

FIG. 9 shows results of a field spray deposition study conducted on bare ground. Spray coverage was determined by analyzing the distribution of droplets on a strip of paper across the 60 ft plot area. The oil-emulsion adjuvant had minimal effect on max % coverage and mean % coverage, and reduced the area under the spray coverage progress curve. In contrast, the oil-emulsion + PAM (PAM DRA3) reduced the swath width, increased the max and mean % coverage, and increased the area under the coverage progress curve.

15 DEFINITIONS

Unless otherwise defined herein, scientific and technical terms used in connection with the present disclosure shall have the meanings that are commonly understood by those of ordinary skill in the art. The meaning and scope of the terms should be clear; in the event, however of any latent ambiguity, definitions provided herein take precedent over any dictionary or extrinsic definition. Further, unless otherwise required by context, singular terms shall include pluralities and plural terms shall include the singular.

The terms “comprise(s),” “include(s),” “having,” “has,” “can,” “contain(s),” and variants thereof, as used herein, are intended to be open-ended transitional phrases, terms, or words that do not preclude the possibility of additional acts or structures. The singular forms “a,” “and” and “the” include plural references unless the context clearly dictates otherwise. The present disclosure also contemplates other embodiments “comprising,” “consisting of” and “consisting essentially of,” the embodiments or elements presented herein, whether explicitly set forth or not.

The term “pesticide” as used herein is used in the broadest sense and refers to any agent

used to destroy, prevent damage from, disrupt, or otherwise control pests. The term “pest” is inclusive of any organism that would potentially be harmful to cultivated plants (c.g. crops), including insects in their various life stages, fungi, bacteria, weeds, nematodes, mites, and the like. The term “pesticide” is inclusive of insecticides, herbicides, bactericides, fungicides, larvicides, nematocides, miticides, plant growth regulators, and the like.

For the recitation of numeric ranges herein, each intervening number there between with the same degree of precision is explicitly contemplated. For example, for the range of 6-9, the numbers 7 and 8 are contemplated in addition to 6 and 9, and for the range 6.0-7.0, the number 6.0, 6.1, 6.2, 6.3, 6.4, 6.5, 6.6, 6.7, 6.8, 6.9, and 7.0 are explicitly contemplated.

Preferred methods and materials are described below, although methods and materials similar or equivalent to those described herein can be used in practice or testing of the present disclosure. All publications, patent applications, patents and other references mentioned herein are incorporated by reference in their entirety. The materials, methods, and examples disclosed herein are illustrative only and not intended to be limiting.

DETAILED DESCRIPTION

The use of unmanned aerial vehicles (UAVs) in agriculture is expanding at a rapid pace due to superiority in precision, efficiency, and safety. However, the risk of drift using UAV-based application is a concern. Drifting agricultural chemicals can reach and adversely affect neighboring people, livestock, wild animals, crops, water sources, and the like. Spray drift is affected by characteristics of the spray solution, environmental parameters (e.g., wind, humidity, etc.), application parameters (e.g., application height, speed, etc.), and characteristics of the application environment. Studies have been conducted to evaluate drift potential for applications performed using hydraulic nozzles typically used in spray vehicles, spray aircraft, etc. However, UAV-based application increasingly using rotary atomizers instead of nozzles are becoming increasingly more common, and the impact of rotary (e.g., centrifugal) atomization on drift is not well-understood. Moreover, UAVs spray at a higher distance from the crop canopy and may fly faster than ground-based spraying equipment, which could further increase drift.

The present invention is predicated, at least in part, on the surprising discovery that oil

emulsion adjuvants, when added to pesticides such as herbicides and fungicides, in some instances cause decreased average particle size and increased driftable fractions to be produced from a rotary atomizer compared to the pesticide product without the added oil emulsion adjuvants. Accordingly, oil emulsion adjuvants such as crop oil concentrates, methylated seeds oils, high surfactant oil concentrates, and oil emulsion-based drift reduction adjuvants (DRAs) commonly used with traditional hydraulic spray nozzles may increase drift when used with rotary atomizers, such as those used in conjunction with UAV-based application. The present invention addresses this problem by providing compositions comprising polyacrylamide, such as polyacrylamide microemulsions, which are shown herein to increase average particle size and reduce the driftable fraction of particles produced by a rotary atomizer. Accordingly, polyacrylamide (e.g., a polyacrylamide microemulsion) can be used in conjunction with oil-based agricultural products, including oil emulsions, oil emulsion concentrates, oil-based pesticides, and the like, to reduce drift when applied with a rotary atomizer.

In some aspects, provided herein are compositions. In some embodiments, provided herein are compositions comprising at least one of a pesticide and a crop protection enhancing adjuvant, and a polyacrylamide. For example, in some embodiments provided herein are compositions comprising a pesticide and a polyacrylamide. In some embodiments provided herein are compositions comprising a crop protection enhancing adjuvant and a polyacrylamide. In some embodiments, provided herein are compositions comprising a pesticide, a crop protection enhancing adjuvant, and a polyacrylamide.

The term “polyacrylamide” (abbreviated as PAM) as used herein refers to a polymer with an acrylic monomer present as one of its monomers. In some embodiments, polyacrylamide refers to a polymer with acrylamide present as one of its monomers. In some embodiments, polyacrylamide is a polymer comprising acrylamide. In some embodiments, polyacrylamide is a polymer comprising the combination of acrylamide and acrylic acid or a derivative thereof (e.g., a salt, ester, or conjugate base of acrylic acid, referred to as an acrylate). The polyacrylamide polymer itself comes in several types, defined by the electrical charge of the polymer chain. The polyacrylamide polymer may be nonionic, anionic or cationic. The cationic (e.g., positively charged) polymer is commonly used in water treatment. In agricultural applications, the cationic polymer is rarely used, as it has a deleterious effect on aquatic wildlife. The nonionic or

uncharged form is a reaction product of pure acrylamide, forming an uncharged, but water-soluble polymer that is quite inert in the environment.

Acrylamide is co-reacted with other monomers to form the cationic or anionic forms. To form the anionic (negatively charged) polymer, acrylamide is most often reacted with an acrylate monomer that is further reacted so that it becomes negatively charged. The nonionic and anionic polymers have different properties. At lower levels in water, the anionic polymers build properties, such as viscosity, faster. Anionic polyacrylamide polymers are compatible with other charged molecules, such as those contained in fertilizers. However, they can react undesirably with certain other charged molecules. Thus, nonionic polyacrylamides are used in situations where the anionics are incompatible with other molecules.

The amount of charge is measured as a percent of the comonomer added. Thus, a polyacrylamide that is 30% acrylate and 70% acrylamide is called a 30 percent-charged polymer. This percentage may be expressed as weight or mole percent, depending on the manufacturer. Typically, if the polymer is a combination of the two monomers, the acrylic acid portion is reacted with base to form the acid salt. The polymer is then considered to be charged.

In some embodiments, the composition comprises a water soluble polyacrylamide. For example, in some embodiments the composition comprises a water-soluble linear polyacrylamide. In some embodiments, the polyacrylamide is a water-dispersible solid polyacrylamide. In some embodiments, the polyacrylamide is a water-dispersed polyacrylamide. For example, in some embodiments a composition provided herein comprises a water soluble polyacrylamide and a non-oil based pesticide (e.g. a water-based pesticide), wherein the water soluble polyacrylamide increases the average particle size and/or reduces the driftable fraction of the composition compared to the average particle size and/or driftable fraction of an equivalent composition lacking the water soluble polyacrylamide.

In some embodiments, the composition comprises a polyacrylamide emulsion. For example, in some embodiments the composition comprises a polyacrylamide emulsion comprising a water-soluble polyacrylamide contained within water particles (the discontinuous phase) dispersed within an oil (the continuous phase). In some embodiments, the composition comprises a polyacrylamide microemulsion. The term “microemulsion” as used herein refers to an emulsion containing polyacrylamide particles having a diameter of 1 nm to 300 nm.

Microemulsion PAMs are described in U.S. Patent Nos. 9,428,630, 9,631,082, 10,138,366, 10,647,845, 9,357,769, 9,309,378, and 9,307,758, and in PCT Publication No. WO2020186182, the entire contents of each of which are incorporated herein by reference.

5 In some embodiments, the microemulsion PAM is an inverse microemulsion. As used herein, the terms “inverse microemulsion,” “inverted emulsion,” “invert emulsion,” or “reverse emulsion” are used interchangeably and refer to a water-in-oil microemulsion (w/o microemulsion) in which an aqueous phase (the discontinuous phase) is dispersed in an oil phase (the continuous phase). In some embodiments, an “inverse emulsion” refers to an emulsion wherein aqueous micelles are dispersed in an oil phase. In some embodiments, the compositions
10 comprising polyacrylamide described herein function as a drift reduction agent (DRA) in agricultural applications. For example, in some embodiments inverse microemulsion PAMs function as a lipophilic drift reduction agent (DRA), such as for pesticide formulations or formulations containing a crop protection enhancing adjuvant, such as fertilizer formulations.

In some embodiments, the microemulsion PAM is transparent/semitransparent inverse
15 microlattices of polyacrylamide (PAM). The transparent/semitransparent inverse microlattice of polyacrylamide (PAM) may be manufactured as described in U.S. Pat. No. 4,681,912, which is incorporated herein by reference, and which specific reference is made to column 2, line 15 to column 3, line 31. Polytex A 33 MC is an exemplary commercial source of polyacrylamide transparent/semitransparent inverse microlattices. As used herein, a “transparent inverse
20 microemulsion” refers to an emulsion having an average particle size of 150 nm or less. As used herein, a “semitransparent inverse microemulsion” refers to an emulsion having an average particle size close to but may somewhat exceed 150 nm, such as up to 300 nm, with the result that the formulation has a cloudy appearance.

The transparent/semitransparent inverse microlattice of polyacrylamide (PAM) may
25 include at least one or all of the following: acrylic monomers (in aqueous solution), at least one hydrocarbon liquid (in organic phase), and at least one non-ionic or anionic surfactant. The acrylic monomers content of the aqueous phase may range from 20-80% by weight. The acrylic monomers may comprise acrylamide, methacrylamide, acrylic acid or an alkali salt thereof, and methacrylic acid or an alkali salt thereof. The pH of the aqueous solution of acrylic monomers
30 may range from 8 to 13. The organic phase may comprise a hydrocarbon or mixture of

hydrocarbons, e.g., isoparaffinic hydrocarbons. The weight ratio of the aqueous phase to the hydrocarbon phase is usually as high as possible, for example from 0.5 to 3:1. At least one non-ionic or anionic surfactant may have a hydrophilic lipophilic balance (HLB) value ranging from 8-11.

5 In some embodiments, the microemulsion PAM comprises polyacrylamide with less than 30 mole % anionic charge. In preferred embodiments, the polyacrylamide of the microemulsion has a 0-22 mole % anionic charge, wherein a 0% charge corresponds to non-ionic PAM. It is more desirable that the anionic charge be in a range of 3-18 mole %, and still more desirable in a range of 7-15 mole % anionic charge. The highest anionic charge with compatibility is most
10 preferred (e.g., 15-22 mole %) to produce the desired property and performance results with the lowest inclusion rate of the small particle size emulsion PAM.

 In some embodiments, the composition produces particles (e.g., droplets) when released from a rotary atomizer. The term “rotary atomizer” refers to an article that uses a rotating component (e.g., disk, cup, wheel) to discharge liquid at high speed to the perimeter of the
15 article, forming a spray (e.g., a hollow cone spray) containing micron-sized droplets. Generally, rotary atomizers operate on the principle of centrifugal energy which produces a high relative speed between the fluid and the air, inducing atomization. In some embodiments of a rotary atomizer, the liquid first flows radially outwards in the rotating component and is then released from the outer boundary of the component at a high speed. Atomization depends on the flow
20 rate of the liquid and the rotational speed of the rotating component. Rotary atomizers rely on mechanical (e.g., centrifugal) force, and thus neither a high-pressure liquid nor a pressurized gas is required to induce atomization of the fluid. For example, in some embodiments a rotary atomizer functions using less than 10 psi of pressure (e.g., 5 psi), whereas traditional, non-rotary
25 sprayers require significantly more pressure (e.g., 40 psi) to produce an adequate spray.

 In some embodiments, the particles released from the rotary atomizer have an average diameter that is larger than the average diameter of particles produced by an equivalent composition lacking the polyacrylamide. In other words, in some embodiments, particles released from a rotary atomizer from a composition comprising polyacrylamide, as described herein, are of larger average diameter than particles released from a rotary atomizer from an

equivalent composition (e.g., a composition comprising the same pesticide and/or the same crop protection enhancing adjuvant) lacking the polyacrylamide.

In some embodiments, the size of the particles released from the rotary atomizer depends on the speed at which the rotating component (e.g., disk) rotates. Accordingly, in some
5 embodiments the speed of the rotating component of a rotary atomizer can be modified to produce particles of the desired size, with the desired drift-reducing properties. In general, a higher disk speed produces finer droplets (e.g., droplets of a smaller size) whereas a lower disk speed produces coarser droplets (e.g., droplets of a larger size). In some embodiments, the average diameter of the particles produced from a rotary atomizer for the composition containing
10 polyacrylamide described herein is larger than the average diameter of particles produced from a rotary atomizer for a composition lacking polyacrylamide, regardless of the speed of the rotating component of the rotary atomizer. In some embodiments, the average diameter of the particles produced from the rotary atomizer depends, at least in part, on the components present within the composition, such as the pesticide, the crop protection enhancing adjuvant, and/or the relative
15 amounts thereof present within the composition.

In some embodiments, the average diameter of particles produced by the composition containing polyacrylamide when released from a rotary atomizer is greater than about 150 microns. In some embodiments, the average diameter of particles produced by the composition containing polyacrylamide when released from a rotary atomizer is greater than about 200
20 microns, about 250 microns, about 300 microns, about 350 microns, about 400 microns, about 450 microns, about 500 microns, about 550 microns, about 600 microns, about 650 microns, about 700 microns, about 750 microns, or about 800 microns. In some embodiments, the average diameter of particles produced by the composition containing polyacrylamide when released from a rotary atomizer at a disk speed of about 8000 rpm is greater than about 150
25 microns. In some embodiments, the average diameter of particles produced by the composition containing polyacrylamide when released from a rotary atomizer at a disk speed of about 4000 rpm is greater than about 440 microns. In some embodiments, the average diameter of particles produced by the composition containing polyacrylamide when released from a rotary atomizer at a disk speed of 2000 rpm is greater than about 450 microns, about 460 microns, about 470
30 microns, about 480 microns, about 490 microns, about 500 microns, about 510 microns, about

520 microns, or about 530 microns. In some embodiments, the average diameter of particles produced by the composition comprising polyacrylamide when released from a rotary atomizer is at least about 10% larger (e.g. at least about 10% larger, at least about 15% larger, at least about 20% larger, at least about 25% larger, at least about 30% larger, at least about 35% larger, at least about 40% larger, at least about 45% larger, or at least about 50% larger) than the average diameter of particles released from a rotary atomizer of by an equivalent composition lacking the polyacrylamide (e.g. a composition comprising at least one of a pesticide and a crop protection enhancing adjuvant but not comprising the polyacrylamide).

In some embodiments, the average diameter of particles produced by an equivalent composition lacking the polyacrylamide (e.g., a composition comprising at least one of a pesticide and a crop protection enhancing adjuvant but not comprising the polyacrylamide) when released from a rotary atomizer is less than about 300 microns. In some embodiments, the average diameter of particles produced by an equivalent composition lacking the polyacrylamide when released from a rotary atomizer is less than about 300 microns, and addition of the polyacrylamide to create a composition as described herein comprising at least one of a pesticide and a crop protection enhancing adjuvant and a polyacrylamide (e.g., a polyacrylamide microemulsion) increases the average diameter of the particles when released from a rotary atomizer to greater than about 300 microns. In some embodiments, the average diameter of particles released from a rotary atomizer by an equivalent composition lacking the polyacrylamide is less than about 300 microns, less than about 290 microns, less than about 280 microns, less than about 270 microns, less than about 260 microns, less than about 250 microns, less than about 240 microns, less than about 230 microns, less than about 220 microns, less than about 210 microns, less than about 200 microns, less than about 190 microns, less than about 180 microns, less than about 170 microns, less than about 160 microns, less than about 150 microns, less than about 140 microns, less than about 130 microns, less than about 120 microns, less than about 110 microns, less than about 100 microns, or less than about 90 microns, and addition of the polyacrylamide to create a composition as described herein comprising at least one of a pesticide and a crop protection enhancing adjuvant and a polyacrylamide (e.g., a polyacrylamide microemulsion) increases the average diameter of the particles when released from a rotary atomizer by at least about 10%. For example, in some embodiments the average diameter of particles released from a rotary atomizer is less than about 300 microns, and addition of the

polyacrylamide to create a composition as described herein comprising at least one of a pesticide and a crop protection enhancing adjuvant and a polyacrylamide (e.g., a polyacrylamide microemulsion) increases the average diameter of the particles when released from a rotary atomizer by at least about 10%, at least about 15%, at least about 20%, at least about 25%, at least about 30%, at least about 35%, at least about 40%, at least about 45%, or at least about 50%.

In some embodiments, the compositions comprising polyacrylamide have a reduced drift potential when released from a rotary atomizer compared to the drift potential of equivalent compositions lacking the polyacrylamide when released from a rotary atomizer. In some embodiments, drift potential is dependent at least in part on the average diameter of particles released from the rotary atomizer. Generally, a spray containing a high percentage of smaller particles has a higher drift potential than a spray containing a lower percentage of smaller particles (e.g., a higher percentage of larger particles). Accordingly, in some embodiments it is advantageous to select appropriate components and amounts thereof in the composition, and to select an appropriate speed of the rotating component of the rotary atomizer, to optimize the coverage area of an application of a spray while minimizing drift. In some embodiments, spray containing a higher percentage of particles having a diameter of less than 141 microns has increased drift potential compared to spray containing a lower percentage of particles having a diameter of less than 141 microns. In some embodiments, the percentage of particles having a diameter of less than 141 microns is referred to herein as a “driftable fraction.” A smaller driftable fraction indicates a reduced drift potential.

In some embodiments, the driftable fraction of particles produced by the composition comprising polyacrylamide when released from a rotary atomizer is less than the driftable fraction of particles produced by an equivalent composition lacking the polyacrylamide when released from a rotary atomizer. In some embodiments, the driftable fraction of particles produced by a rotary atomizer depends on the speed at which the rotating component (e.g., disk) rotates. Generally, a higher disk speed produces finer particles, and therefore increases the driftable fraction of particles produced by the rotary atomizer compared to the driftable fraction produced by a lower disk speed. In some embodiments, the driftable fraction of particles (e.g., the percentage of particles having a diameter of less than 141 microns) produced by the

composition comprising polyacrylamide when released from a rotary atomizer is less than the driftable fraction of particles produced by an equivalent composition lacking the polyacrylamide, regardless of the speed of the rotating component of the rotary atomizer.

In some embodiments, the driftable fraction of particles produced by the composition comprising polyacrylamide when released from a rotary atomizer is less than 75%. In some embodiments, the driftable fraction of particles produced by the composition comprising polyacrylamide when released from a rotary atomizer is less than 70%. In some embodiments, the driftable fraction of particles produced by the composition comprising polyacrylamide when released from a rotary atomizer is less than 70%, less than 68%, less than 66%, less than 64%, less than 62%, less than 60%, less than 58%, less than 56%, less than 54%, less than 52%, less than 50%, less than 45%, less than 40%, less than 35%, less than 30%, less than 25%, less than 20%, less than 15%, or less than 10%. In some embodiments, the driftable fraction of particles produced by the composition comprising polyacrylamide when released from a rotary atomizer is less than 1%. In some embodiments, the driftable fraction of particles produced by the composition comprising polyacrylamide when released from a rotary atomizer is less than 1%, less than 0.9%, less than 0.8%, less than 0.7%, less than 0.6%, less than 0.5%, less than 0.4%, less than 0.3%, less than 0.2%, or less than 0.1%.

In some embodiments, the driftable fraction of particles produced by an equivalent composition lacking the polyacrylamide (e.g. a composition comprising at least one of a pesticide and a crop protection enhancing adjuvant but not comprising the polyacrylamide) when released from a rotary atomizer is about 60% to about 90%, and addition of the polyacrylamide to create a composition as described herein comprising at least one of a pesticide and a crop protection enhancing adjuvant and a polyacrylamide (e.g. a polyacrylamide microemulsion) decreases the driftable fraction of particles by at least about 5%. In some embodiments, the driftable fraction of particles produced by an equivalent composition lacking the polyacrylamide when released from a rotary atomizer is about 60% to about 90%, and addition of the polyacrylamide to create a composition as described herein comprising at least one of a pesticide and a crop protection enhancing adjuvant and a polyacrylamide decreases the driftable fraction of particles by at least about 10%. In some embodiments, the driftable fraction of particles produced by an equivalent composition lacking the polyacrylamide when released from a rotary

atomizer is about 60% to about 90%, and addition of the polyacrylamide to create a composition as described herein comprising at least one of a pesticide and a crop protection enhancing adjuvant and a polyacrylamide decreases the driftable fraction of particles by at least about 15%. In some embodiments, the driftable fraction of particles produced by an equivalent composition lacking the polyacrylamide when released from a rotary atomizer is about 60% to about 90%, and addition of the polyacrylamide to create a composition as described herein comprising at least one of a pesticide and a crop protection enhancing adjuvant and a polyacrylamide decreases the driftable fraction of particles by at least about 20%.

In some embodiments, the composition comprises one or more crop protection enhancing adjuvants. In some embodiments, it is desirable to combine the attributes of microemulsion PAM with other crop protection enhancing adjuvants. Crop protection enhancing adjuvants are also referred to herein as adjuvants. Adjuvants are described by ASTM E1519 as a material added to a tank mix to aid or modify the action of an agrichemical or the physical characteristics of the mixture. Such materials include, but are not limited to, crop oil concentrates, modified vegetable oils (MVO), drift retardants, and nonionic surfactants. In some embodiments, the crop protection enhancing adjuvant is selected from the group consisting of: crop oil concentrates (e.g., paraffinic oils), modified vegetable oils (e.g., soybean oil ethoxylates, ethoxylated lecithin), drift retardants, soil or foliage penetrants, buffering agents, wetting agents, surfactants (e.g., non-ionic surfactants (EO-PO block copolymers) anionic surfactants, cationic surfactants and amphoteric, nitrogen fertilizers, compatibility agents, defoamers, deposition agents, or combinations thereof.

In some embodiments, the crop protection enhancing adjuvant is a lipophilic adjuvant. Lipophilic adjuvant components include, but are not limited to, paraffin oils, white oils, aromatics, naphthenes, alkenes, and fatty oils such as mineral oils, modified vegetable (seed) oils and derivatives. Vegetable oils and derivatives include soybean, canola, coconut, corn, cottonseed, palm, palm kernel, flaxseed, grape seed, peanut, safflower and sunflower, and ethoxylated seed oils, such as ethoxylated soybean oil, ethoxylated methyl esters, such as ethoxylated soybean methyl ester, and ethylated methyl esters. Generally, the fatty acids and derivatives are 10 carbons (preferably 0 double bonds) to 18 carbons (preferably 3 double bonds) in length.

Crop protection enhancing adjuvants can affect the surface-active properties of pesticide or fertilizer applications positively by increasing pest control attributes, such as increased ability to penetrate waxy cuticles of leaf surfaces and increase droplet spreading on leaf or target surfaces. In some embodiments, it is desirable to combine the properties of oil-based adjuvants with the drift retardant properties of a composition comprising polyacrylamide, such as a polyacrylamide microemulsion, for use in spray applications of pesticides and/or fertilizers.

In some embodiments, the composition combines the polyacrylamide (e.g. the polyacrylamide microemulsion) with lipophilic adjuvant components in a user-friendly formulation. These formulations overcome the compatibility and handling challenges of solution-based and macroemulsion polyacrylamides while formulating with desirable pest control adjuvant materials.

Many pest control formulations, especially lipophilic herbicides, are well suited to perform or enhance weed control when tank mixed with lipophilic adjuvants such as modified vegetable oils (MVO), also referred to herein as modified seed oils (MSO), crop oil concentrates (COC), high surfactant oil concentrates (HSOC), and other lipophilic deposition aids. These classes of adjuvant types are described by ASTM as follows: MVO is an oil, extracted from seeds, that has been chemically modified (e.g., methylated); COC is an emulsifiable petroleum oil-based product containing 15 to 20% w/w surfactant and a minimum of 80% w/w phyto bland oil, and HSOC is an emulsifiable oil based product containing 25-50% w/w surfactant and a minimum of 50% w/w oil. See E1519 publications from ASTM. When combined, lipophilic properties of adjuvants and herbicides are well suited to penetrate waxy cuticles of weeds species such as broadleaf and grasses. Lipophilic adjuvants are carriers of the lipophilic herbicides, such as clethodim, into the vascular system of weeds. The herbicides and lipophilic adjuvants are diluted in tank mix water solutions or diluted directly in oil and sprayed for use to control weeds. Once the water evaporates off of a weed surface, the oil carrier and herbicide continue to diffuse through leaf cuticles for both contact and systemic herbicides. Systemic herbicides move through the vascular system of the weed and to the root which is key to weed control and is enabled by lipophilic adjuvants. In some embodiments, the compositions comprising a polyacrylamide are combined with lipophilic herbicides and lipophilic adjuvants to promote highly effective weed control while minimizing drift.

In some embodiments, the composition comprises at least one pesticide. Examples of pesticides include, but are not limited to, acaricides, avicides, chemosterilants, herbicides, insecticides, molluscicides, plant growth regulators, virucides, algicides, bactericides, fungicides, insect attractants, mammal repellents, nematocides, rodenticides, antifeedants, bird repellents, herbicide safeners, insect repellents, mating disrupters, plant activators, and the like. In some embodiments, the pesticide comprises an insecticide, an herbicide, a bactericide, a fungicide, a larvicide, or a combination thereof. The pesticide may be a lipophilic pesticide. In some embodiments, the composition may further comprise a crop protection enhancing adjuvant, as described above. In some embodiments the pesticide is an oil-based pesticide and the polyacrylamide is a polyacrylamide emulsion, such as a polyacrylamide microemulsion. In some embodiments, the pesticide is not oil-based (e.g. is water-based), and the polyacrylamide is a water-soluble polyacrylamide.

In some embodiments, the pesticide comprises an herbicide. The present disclosure is not limited to a particular herbicide. Examples of herbicides that can be used in a composition described herein include, but are not limited to, amide herbicides (e.g., allidochlor, amicarbazone, beflubutamid, benzadox, benzipram, bromobutide, cafenstrole, CDEA, cyprazole, dimethenamid (e.g., dimethenamid-P), diphenamid, epronaz, etniproamid, fentrazamide, flucarbazone, flupoxam, fomesafen, halosafen, huangcaoling, isocarbamid, isoxaben, napropamide, naptalam, pethoxamid, propyzamide, quinonamid, saflufenacil, tebutam); anilide herbicides (e.g., chloranocryl, cisanilide, clomeprop, cypromid, diflufenican, erlujixiancaolan, etobenzanid, fenasulam, flufenacet, flufenican, ipfencarbazone, mefenacet, mefluidide, metamifop, monalide, naproanilide, pentanochlor, picolinafen, propanil, sulfentrazone); arylalanine herbicides (e.g., benzoxyprop, flamprop (e.g., flamprop-M)); chloroacetanilide herbicides (e.g., acetoachlor, alachlor, butachlor, butenachlor, delachlor, diethatyl, dimethachlor, ethachlor, ethapachlor, metazachlor, metolachlor (e.g., S-metolachlor), pretilachlor, propachlor, propisochlor, prynachlor, terbuchlor, thenylchlor, xylachlor); sulfonanilide herbicides (e.g., benzoxyfluor, cloransulam, diclosulam, florasulam, flumetsulam, metosulam, perfluidone, pyrimisulfan, proflumazone); sulfonamide herbicides (e.g., asulam, carbasulam, fenasulam, oryzalin, penoxsulam, pyroxsulam, see also sulfonylurea herbicides); thioamide herbicides (e.g., bencarbazone, chlorthiamid); antibiotic herbicides (e.g., bilanafos); aromatic acid herbicides (e.g., benzoic acid herbicides (e.g., chloramben, dicamba, 2,3,6-TBA, tricamba);

pyrimidinyloxybenzoic acid herbicides (e.g., bispyribac, pyriminobac); pyrimidinylthiobenzoic acid herbicides (e.g., pyriothiobac); phthalic acid herbicides (e.g., chlorthal); picolinic acid herbicides (e.g., aminopyralid, clopyralid, picloram); quinolinecarboxylic acid herbicides (e.g., quinclorac, quinmerac)); arsenical herbicides (e.g., cacodylic acid, CMA, DSMA, hexaflurate, MAA, MAMA, MSMA, potassium arsenite, sodium arsenite); benzoylcyclohexanedione herbicides (e.g., ketospiradox, mesotrione, sulcotrione, tefuryltrione, tembotrione); benzofuranyl alkylsulfonate herbicides (e.g., benfuresate, ethofumesate); benzothiazole herbicides (e.g., benazolin, benzthiazuron, fenthiaprop, mefenacet, methabenzthiazuron); carbamate herbicides (e.g., asulam, carboxazole, chlorprocarb, dichlormate, fenasulam, karbutilate, terbucarb);

10 carbanilate herbicides (e.g., barban, BCPC, carbasulam, carbetamide, CEPC, chlorbufam, chlorpropham, CPPC, desmedipham, phenisopham, phenmedipham, phenmedipham-ethyl, propham, swep); cyclohexene oxime herbicides (e.g., alloxydim, butroxydim, clethodim, cloproxydim, cycloxydim, profoxydim, sethoxydim, tepraloxym, tralkoxydim); cyclopropylisoxazole herbicides (e.g., isoxachlortole, isoxaflutole); dicarboximide herbicides

15 (e.g., cinidon-ethyl, flumezin, flumiclorac, flumioxazin, flumipropyn, see also uracil herbicides); dinitroaniline herbicides (e.g., benfluralin, butralin, chlormidine, dinitramine, dipropalin, ethalfluralin, fluchloralin, isopropalin, methalpropalin, nitratin, oryzalin, pendimethalin, prodiamine, profluralin, trifluralin); dinitrophenol herbicides (e.g., dinofenat, dinoprop, dinosam, dinoseb, dinoterb, DNOC, etinofen, medinoterb); diphenyl ether herbicides (e.g.,

20 ethoxyfen); nitrophenyl ether herbicides (e.g., acifluorfen, aclonifen, bifenox, chlomethoxyfen, chlornitrofen, etniproimid, fluorodifen, fluoroglycofen, fluoronitrofen, fomesafen, fucaomi, furyloxyfen, halosafen, lactofen, nitrofen, nitrofluorfen, oxyfluorfen); dithiocarbamate herbicides (e.g., dazomet, metam); halogenated aliphatic herbicides (e.g., alorac, chloropon, dalapon, flupropanate, hexachloroacetone, methyl bromide, methyl iodide,

25 monochloroacetic acid, SMA, TCA); imidazolinone herbicides (e.g., imazamethabenz, imazamox, imazapic, imazapyr, imazaquin, imazethapyr); inorganic herbicides (e.g., ammonium sulfamate, borax, calcium chlorate, copper sulfate, ferrous sulfate, potassium azide, potassium cyanate, sodium azide, sodium chlorate, sulfuric acid); nitrile herbicides (e.g., bromobonil, bromoxynil, chloroxynil, dichlobenil, iodobonil, ioxynil, pyraclonil); organophosphorus

30 herbicides (e.g., amiprofos-methyl, amiprofos, anilofos, bensulide, bilanafos, butamifos, 2,4-DEP, DMPA, EBEP, fosamine, glufosinate (e.g., glufosinate-P, glyphosate, huangcaoling

piperophos); oxadiazolone herbicides (e.g., dimefuron, methazole, oxadiargyl, oxadiazon);
 oxazole herbicides (e.g., carboxazole, fenoxasulfone, isouron, isoxaben, isoxachlortole,
 isoxaflutole, methiozolin, monisouron, pyroxasulfone, topramezone); phenoxy herbicides (e.g.,
 bromofenoxim, clomeprop, 2,4-DEB, 2,4-DEP, difenopenten, disul, erbon, etnipromid,
 5 fenteracol, trifopsime); phenoxyacetic herbicides (e.g., 4-CPA, 2,4-D, 3,4-DA, MCPA, MCPA-
 thioethyl, 2,4,5-T); phenoxybutyric herbicides (e.g., 4-CPB, 2,4-DB, 3,4-DB, MCPB, 2,4,5-TB);
 phenoxybutyric herbicides (e.g., 4-CPB, 2,4-DB, 3,4-DB, MCPB, 2,4,5-TB); phenoxypropionic
 herbicides (e.g., cloprop, 4-CPP, dichlorprop (e.g., dichlorprop-P), 3,4-DP, fenoprop, mecoprop
 (e.g., mecoprop-P); aryloxyphenoxypropionic herbicides (e.g., chlorazifop, clodinafop, clofop,
 10 cyhalofop, diclofop, fenoxaprop (e.g., fenoxaprop-P); fenthiaprop, fluazifop (e.g., fluazifop-P),
 haloxyfop (e.g., haloxyfop-P), isoxapyrifop, metamifop, propaquizafop, quizalofop (e.g.,
 quizalofop-P), trifop); phenylenediamine herbicides (e.g., dinitramine, prodiamine); pyrazole
 herbicides (e.g., azimsulfuron, difenzoquat, halosulfuron, metazachlor, metazosulfuron,
 pyrazosulfuron, pyroxasulfone); pyrazole herbicides (e.g., benzoferap, pyrasulfotole,
 15 pyrazolynate, pyrazoxyfen, topramezone); phenylpyrazole herbicides (e.g., fluazolate,
 nipyraclufen, pinoxaden, pyraflufen); pyridazine herbicides (e.g., credazine, pyridafol, pyridate);
 pyridazinone herbicides (e.g., brompyrazon, chloridazon, dimidazon, flufenpyr, metflurazon,
 norflurazon, oxapyrazon, pydanon); pyridine herbicides (e.g., aminopyralid, clodinate,
 clopyralid, diflufenican, dithiopyr, flufenican, fluroxypyr, haloxydine picloram, picolinafen,
 20 pyriclor, pyroxsulam, thiazopyr, triclopyr); pyrimidinediamine herbicides (e.g., iprymidam,
 tioclorim); pyrimidinyloxybenzylamine herbicides (e.g., pyribambenz-isopropyl,
 pyribambenzpropyl); quaternary ammonium herbicides (e.g., cyperquat, diethamquat,
 difenzoquat, diquat, morfamquat, paraquat); thiocarbamate herbicides (e.g., butylate, cycloate,
 diallate, EPTC, esprocarb, ethiolate, isopolinate, methiobencarb, molinate, orbencarb, pebulate,
 25 prosulfocarb, pyributicarb, sulfallate, thiobencarb, tiocarbazil, tri-allate, vernolate); thiocarbonate
 herbicides (e.g., dimexano, EXD, proxan); thiourea herbicides (e.g., methiuron); triazine
 herbicides (e.g., dipropetryn, fucaojing, trihydroxytriazine); chlorotriazine herbicides (e.g.,
 atrazine, chlorazine, cyanazine, cyprazine, eglinazine, ipazine, mesoprazine, procyazine,
 proglinazine, propazine, sebuthylazine, simazine, terbuthylazine, trietazine); fluoroalkyltriazine
 30 herbicides (e.g., indaziflam, triaziflam); methoxytriazine herbicides (e.g., atraton, methometon,
 prometon, sebumeton, simeton, terbumeton); methylthiotriazine herbicides (e.g., ametryn,

aziprotryne, cyanatryn, desmetryn, dimethametryn, methoprotryne, prometryn, simetryn, terbutryn); triazinone herbicides (e.g., ametrion, amibuzin, ethiozin, hexazinone, isomethiozin, metamitron, metribuzin); triazole herbicides (e.g., amitrole, cafenstrole, epronaz, flupoxam); triazolone herbicides (e.g., amicarbazone, bencarbazone, carfentrazone, flucarbazone, ipfencarbazone, propoxycarbazone, sulfentrazone, thienicarbazone); triazolopyrimidine herbicides (e.g., cloransulam, diclosulam, florasulam, flumetsulam, metosulam, penoxsulam, pyroxsulam); uracil herbicides (e.g., benzfendazole, bromacil, butafenacil, flupropacil, isocil, lenacil, saflufenacil, terbacil); urea herbicides (e.g., benzthiazuron, cumyluron, cycluron, dichloralurea, diflufenzopyr, isonoruron, isouron, methabenzthiazuron, monisouron, noruron); phenylurea herbicides (e.g., anisuron, buturon, chlorbromuron, chloreturon, chlorotoluron, chloroxuron, daimuron, difenoxuron, dimefuron, diuron, fenuron, fluometuron, fluothiuuron, isoproturon, linuron, methiuron, methylidymron, metobenzuron, metobromuron, metoxuron, monolinuron, monuron, neburon, parafluron, phenobenzuron, siduron, tetrafluron, thidiazuron); sulfonylurea herbicides (e.g., pyrimidinylsulfonylurea herbicides (e.g., amidosulfuron, azimsulfuron, bensulfuron, chlorimuron, cyclosulfamuron, ethoxysulfuron, flazasulfuron, flucetosulfuron, flupyrsulfuron, foramsulfuron, halosulfuron, imazosulfuron, mesosulfuron, metazosulfuron, methiopyrisulfuron, nicosulfuron, orthosulfamuron, oxasulfuron, primisulfuron, propyrisulfuron, pyrazosulfuron, rimsulfuron, sulfometuron, sulfosulfuron, trifloxysulfuron), triazinylsulfonylurea herbicides (e.g., chlorsulfuron, cinosulfuron, ethametsulfuron, iodosulfuron, metsulfuron, prosulfuron, thifensulfuron, triasulfuron, tribenuron, triflusulfuron, tritosulfuron)); thiadiazolylurea herbicides (e.g., buthiuron, ethidimuron, tebuthiuron, thiazafuron, thidiazuron); unclassified herbicides (e.g., acrolein, allyl alcohol, aminocyclopyrachlor, azafenidin, bentazone, bentranil, benzobicyclon, bicyclopyrone, buthidazole, calcium cyanamide, cambendichlor, chlorfenac, chlorfenprop, chlorflurazole, chlorflurenol, cinmethylin, clomazone, CPMF, cresol, cyanamide, ortho-dichlorobenzene, dimepiperate, dithioether, endothal, fluoromidine, fluridone, flurochloridone, flurtamone, fluthiacet, indanofan, methoxyphenone, methyl isothiocyanate, OCH, oxaziclonofone, pelargonic acid, pentachlorophenol, pentoxazone, phenylmercury acetate, prosulfalin, pyribenzoxim, pyriftalid, quinclamine, rhodethanil, sulglycapin, thidiazimin, tridiphane, trimeturon, tripropindan, tritac).

In some embodiments, the pesticide comprises an insecticide. Examples of insecticides include, but are not limited to, antibiotic insecticides (e.g., allosamidin, thuringiensin); macrocyclic lactone insecticides (e.g., avermectin insecticides (e.g., abamectin, doramectin, emamectin, eprinomectin, ivermectin, selamectin), milbemycin insecticides (e.g., lepipmectin, milbemectin, milbemycin oxime, and moxidectin), spinosyn insecticides (e.g., spinetoram and spinosad)); arsenical insecticides (e.g., calcium arsenate, copper acetoarsenite, copper arsenate, lead arsenate, potassium arsenite, sodium arsenite); botanical insecticides (e.g., allicin, anabasin, azadirachtin, carvacrol, d-limonene, matrine, nicotine, nornicotine, oxymatrine, pyrethrins (e.g., cinerins, (e.g., cinerin I, cinerin II), jasmolin I, jasmolin II, pyrethrin I, pyrethrin II), quassia, rhodajaponin-III, rotenone, ryania, sabadilla, triptolide); carbamate insecticides (e.g., bendiocarb, carbaryl); benzofuranyl methylcarbamate insecticides (e.g., benfuracarb, carbofuran, carbosulfan, decarbofuran, furathiocarb); dimethylcarbamate insecticides (e.g., dimetan, dimetilan, hyquincarb, isolan, pirimicarb, pyramat); oxime carbamate insecticides (e.g., alanycarb, aldicarb, aldoxycarb, butocarboxim, butoxycarboxim, methomyl, nitrilacarb, oxamyl, tazimcarb, thiocarboxime, thiodicarb, thiofanox); phenyl methylcarbamate insecticides (e.g., allyxycarb, aminocarb, bufencarb, butacarb, carbanolate, cloethocarb, CPMC, dicresyl, dimethacarb, dioxacarb, EMPC, ethiofencarb, fenethacarb, fenobucarb, isoprocarb, methiocarb, metolcarb, mexacarb, promacyl, promecarb, propoxur, trimethacarb, XMC, xylylcarb); desiccant insecticides (e.g., boric acid, diatomaceous earth, silica gel); diamide insecticides (e.g., chlorantraniliprole, cyantraniliprole, flubendiamide); dinitrophenol insecticides (e.g., dinex, dinoprop, dinosam, DNOC); fluorine insecticides (e.g., barium hexafluorosilicate, cryolite, flursulamid, sodium fluoride, sodium hexafluorosilicate, sulfluramid); formamidine insecticides (e.g., amitraz, chlordimeform, formetanate, formparanate, medimeform, semiamitraz); fumigant insecticides (e.g., acrylonitrile, carbon disulfide, carbon tetrachloride, chloroform, chloropicrin, paradichlorobenzene, 1,2-dichloropropane, dithioether, ethyl formate, ethylene dibromide, ethylene dichloride, ethylene oxide, hydrogen cyanide, methyl bromide, methyl iodide, methylchloroform, methylene chloride, naphthalene, phosphine, sulfuric fluoride, tetrachloroethane); inorganic insecticides (e.g., borax, boric acid, calcium polysulfide, copper oleate, diatomaceous earth, mercurous chloride, potassium thiocyanate, silica gel, sodium thiocyanate, see also arsenical insecticides, see also fluorine insecticides); insect growth regulators (e.g., chitin synthesis inhibitors (e.g., bistrifluron, buprofezin, chlorbenzuron,

chlorfluazuron, cyromazine, dichlorbenzuron, diflubenzuron, flucycloxuron, flufenoxuron, hexaflumuron, lufenuron, novaluron, noviflumuron, penfluron, teflubenzuron, triflumuron); juvenile hormone mimics (e.g., dayoutong, epofenonane, fenoxycarb, hydroprene, kinoprene, methoprene, pyriproxyfen, triprene); juvenile hormones (e.g., juvenile hormone I, juvenile hormone II, juvenile hormone III); moulting hormone agonists (e.g., chromafenozide, furan tebufenozide, halofenozide, methoxyfenozide, tebufenozide, yishijing); moulting hormones (e.g., a-ecdysone, ecdysterone); moulting inhibitors (e.g., diofenolan); precocenes (e.g., precocene I, precocene II, precocene III); unclassified insect growth regulators (e.g., dicyclanil)); nereistoxin analogue insecticides (e.g., bensultap, cartap, polythialan, thiocyclam, thiosultap); nicotinoid insecticides (e.g., flonicamid); nitroguanidine insecticides (e.g., clothianidin, dinotefuran, imidacloprid, imidaclothiz, thiamethoxam); nitromethylene insecticides (e.g., nitenpyram, nithiazine); pyridylmethylaniline insecticides (e.g., acetamiprid, imidacloprid, nitenpyram, paichongding, thiacloprid); organochlorine insecticides (e.g., bromo-DDT, camphechlor, DDT (e.g., pp'-DDT), ethyl-DDD, HCH (e.g., gamma-HCH, lindane), methoxychlor, pentachlorophenol, TDE); cyclodiene insecticides (e.g., aldrin, bromocyclen, chlordane, chlordane, chlordecone, dieldrin, dilor, endosulfan (e.g., alpha endosulfan), endrin, HEOD heptachlor, HHDN, isobenzan, isodrin, kelevan, mirex), organophosphorus insecticides (e.g., organophosphate insecticides (e.g., bromfenvinfos, calvinphos, chlorfenvinfos, crotoxyphos, dichlorvos, dicrotophos, dimethylvinphos, fospirate, heptenophos, methocrotophos, mevinphos monocrotophos, naled, naftalofos, phosphamidon, propaphos, TEPP, tetrachlorvinphos); organothiophosphate insecticides (e.g., dioxabenzofos, fosmethilan, phenthoate); aliphatic organothiophosphate insecticides (e.g., acethion, acetophos, amiton, cadusafos, chlorethoxyfos, chlormephos, demephion (e.g., demephion-O, demephion-S), demeton (e.g., demeton-O, demeton-S), demeton methyl (e.g., demeton-O-methyl, demeton-S-methyl), disulfoton, ethion ethoprophos, IP SP, isothioate, malathion, methacrifos, methylacetophos, oxydemetonmethyl, oxydeprofos, oxydisulfoton, phorate, sulfotep, terbufos, thiometon); aliphatic amide organothiophosphate insecticides (e.g., amidithion, cyanthoate, dimethoate, ethoate-methyl, formothion, mecarbam, omethoate, prothoate, sophamide, vamidothion), oxime organothiophosphate insecticides (e.g., chlorphoxim, phoxim, phoxim-methyl); heterocyclic organothiophosphate insecticides (e.g., azamethiphos, colophonate, coumaphos, coumithoate, dioxathion, endothion, menazon, morphothion, phosalone, pyraclofos, pyridaphenthion,

- quinothion); benzothiopyran organothiophosphate insecticides (e.g., dithicrofos, thicrofos);
 benzotriazine organothiophosphate insecticides (e.g., azinphos-ethyl, azinphos-methyl);
 isoindole organothiophosphate insecticides (e.g., dialifos, phosmet); isoxazole
 organothiophosphate insecticides (e.g., isoxathion, zolaprofos); pyrazolopyrimidine
 5 organothiophosphate insecticides (e.g., chlorprazophos, pyrazophos); pyridine
 organothiophosphate insecticides (e.g., chlorpyrifos, chlorpyrifos-methyl); pyrimidine
 organothiophosphate insecticides (e.g., butathiofos, diazinon, etrimfos, lirimfos, pirimioxphos
 pirimiphos-ethyl, pirimiphos-methyl, primidophos, pyrimitate, tebupirimfos); thiadiazole
 organothiophosphate insecticides (e.g., athidathion, lythidathion, methidathion, prothidathion);
 10 triazole organothiophosphate insecticides (e.g., isazofos, triazophos); phenyl
 organothiophosphate insecticides (e.g., azothoate, bromophos, bromophos-ethyl,
 carbophenothion, chlorthiophos, cyanophos, cythioate, dicapthon, dichlofenthion, etaphos,
 famphur, fenchlorphos, fenitrothion, fensulfothion, fenthion, fenthion-ethyl, heterophos,
 jodfenphos, mesulfenfos, parathion, parathion-methyl, phenkapton, phosnichlor, profenofos,
 15 prothiofos, sulprofos, temephos, trichlormetaphos-3, trifenofos, xiaochongliulin)); phosphonate
 insecticides (e.g., butonate, trichlorfon); phosphonothioate insecticides (e.g., mecarphon); phenyl
 ethylphosphonothioate insecticides (e.g., fonofos, trichloronat); phenyl phenylphosphonothioate
 insecticides (e.g., cyanofenphos, EPN, leptophos); phosphoramidate insecticides (e.g.,
 crufomate, fenamiphos, fosthietan, mephosfolan, phosfolan, phosfolan-methyl pirimetaphos);
 20 phosphoramidothioate insecticides (e.g., dimefox, mazidox, mipafox, schradan); oxadiazine
 insecticides (e.g., indoxacarb); oxadiazolone insecticides (e.g., metoxadiazone); phthalimide
 insecticides (e.g., dialifos, phosmet, tetramethrin); pyrazole insecticides (e.g., chlorantraniliprole,
 cyantraniliprole, dimetilan, isolan, tebufenpyrad, tolfenpyrad); phenylpyrazole insecticides (e.g.,
 acetoprole, ethiprole, fipronil, pyraclofos, pyrafluprole, pyriprole, vaniliprole); pyrethroid
 25 insecticides (e.g., pyrethroid ester insecticides (e.g., acrinathrin, allethrin (e.g., bioallethrin,
 esdepallethrine), barthrin, bifenthrin, bioethanomethrin brofenvalerate, brofluthrin,ate,
 bromethrin, butethrin, chlorempenthrin, cyclethrin, cycloprothrin cyfluthrin (e.g., beta-
 cyfluthrin), cyhalothrin (e.g., gamma-cyhalothrin, lambda-cyhalothrin), cypermethrin (e.g.,
 alpha-cypermethrin, beta-cypermethrin, theta-cypermethrin, zeta-cypermethrin), cyphenothrin,
 30 deltamethrin, dimefluthrin, dimethrin, empenthrin, d-fanshiluquebingjuzhi, fenfluthrin,
 fenpirithrin, fenpropathrin, fenvalerate (e.g., esfenvalerate), flucythrinate, fluvalinate (e.g., tau

fluvalinate), furamethrin, furethrin, imiprothrin, japoethrin, kadethrin, meperfluthrin, methothrin, metofluthrin, pentmethrin, permethrin (e.g., biopermethrin, transpermethrin), phenothrin, prallethrin, profluthrin, proparthrin, pyresmethrin, resmethrin (e.g., bioresmethrin, cismethrin), tefluthrin, terallethrin, tetramethrin, tetramethylfluthrin, traloccythrin, tralomethrin, transfluthrin, valerate; pyrethroid ether insecticides (e.g., etofenprox, flufenprox, halfenprox, protrifenbute, silafluofen); pyrethroid oxime insecticides (e.g., sulfoxime, thiofluoximate)); pyrimidinamine insecticides (e.g., flufenerim, pyrimidifen); pyrrole insecticides (e.g., chlorfenapyr); tetramic acid insecticides (e.g., spirotetramat); tetrone acid insecticides (e.g., spiromesifen); thiazole insecticides (e.g., clothianidin, imidaclothiz, thiamethoxam, thiapronil); thiazolidine insecticides (e.g., tazimcarb, thiachlorid); thiourea insecticides (e.g., diafenthiuron); urea insecticides (e.g., flucifuron, sulcofuron, see also chitin synthesis inhibitors); unclassified insecticides (e.g., closantel, copper naphthenate, crotamiton EXD, fenazaflor, fenoxacrim, hydramethylnon, isoprothiolane malonoben, metaflumizone, nifluridide, plifenate, pyridaben, pyridalyl, pyrifluquinazon, rafoxanide, sulfoxaflo, triarathene, triazamate).

In some embodiments, the pesticide is a fungicide. Examples of fungicides include, but are not limited to aliphatic nitrogen fungicides (e.g., butylamine, cymoxanil, dodicin, dodine, guazatine, iminoctadine); amide fungicides (e.g., carpropamid, chloraniformethan, cyflufenamid, diclocymet, ethaboxam, fenoxanil, flumetover, furametypr, isopyrazam, mandipropamid, penthiopyrad, prochloraz, quinazamid, silthiofam, triforine, xiwojunan); acylamino acid fungicides (e.g., benalaxyl (e.g., benalaxyl-M), furalaxyl, metalaxyl (e.g., metalaxyl-M), pefurazoate, valifenalate); anilide fungicides (e.g., benalaxyl (e.g., benalaxyl-M), bixafen, boscalid, carboxin, fenhexamid, fluxapyroxad, isotianil, metalaxyl (e.g., metalaxyl-M), metsulfosax, ofurace, oxadixyl, oxycarboxin, penflufen, pyracarbolid, sedaxane, thifluzamide, tiadinil, vangard); benzanilide fungicides (e.g., benodanil, flutolanil, mebenil, mepronil, salicylanilide, tecloftalam); furanilide fungicides (e.g., fenfuram, furalaxyl, furcarbanil, methfuroxam); sulfonanilide fungicides (e.g., flusulfamide); benzamide fungicides (e.g., benzohydroxamic acid, fluopicolide, fluopyram, tioxyamid, trichlamide, zarilamid, zoxamide); furamide fungicides (e.g., cyclafuramid, furmecyclo); phenylsulfamide fungicides (e.g., dichlofluanid, tolylfluanid); sulfonamide fungicides (e.g., amisulbrom, cyazofamid); valinamide fungicides (e.g., benthiavalicarb, iprovalicarb); antibiotic fungicides (e.g., aureofungin, blastidicin-S, cycloheximide, griseofulvin, kasugamycin, moroxydine, natamycin, polyoxins,

polyoxorim, streptomycin, validamycin); strobilurin fungicides (e.g., azoxystrobin, dimoxystrobin, enestroburin, fluoxastrobin, jiaxiangjunzhi, kresoxim-methyl, metominostrobin, orysastrobin, picoxystrobin, pyraclostrobin, pyrametostrobin, pyraoxystrobin, trifloxystrobin, xiwojunan); aromatic fungicides (e.g., biphenyl, chlorodinitronaphthalenes, chloroneb, chlorothalonil, cresol, dicloran, hexachlorobenzene, pentachlorophenol, quintozone, sodium pentachlorophenoxide, tecnazene); arsenical fungicides (e.g., asomate, urbacide); aryl phenyl ketone fungicides (e.g., metrafenone, pyriofenone); benzimidazole fungicides (e.g., benomyl, carbendazim, chlorfenazole, cypendazole, debacarb, fuberidazole, mecarbinzid, rabenzazole, thiabendazole); benzimidazole precursor fungicides (e.g., furophanate, thiophanate, thiophanate-methyl); benzothiazole fungicides (e.g., bentaluron, benthiavalicarb, benthiazole, chlobenthiazole, probenazole); botanical fungicides (e.g., allicin, berberine, carvacrol, carvone, osthonol); bridged diphenyl fungicides (e.g., bithionol, dichlorophen, diphenylamine, hexachlorophene, parinol); carbamate fungicides (e.g., benthiavalicarb, furophanate, iprovalicarb, propamocarb, pyribencarb, thiophanate, thiophanate-methyl); benzimidazolylcarbamate fungicides (e.g., benomyl, carbendazim, cypendazole, debacarb, mecarbinzid); carbanilate fungicides (e.g., diethofencarb, lvdinjunzhi, pyraclostrobin, pyrametostrobin); conazole fungicides (e.g., conazole fungicides (imidazoles) (e.g., climbazole, clotrimazole, imazalil, oxpoconazole, prochloraz, triflumizole, see also imidazole fungicides), conazole fungicides (triazoles) (e.g., azaconazole, bromuconazole, cyproconazole, diclobutrazol, difenoconazole, diniconazole (e.g., diniconazole-M), epoxiconazole, etaconazole, fenbuconazole, fluquinconazole, flusilazole, flutriafol, furconazole (e.g., furconazole-cis), hexaconazole, imibenconazole, ipconazole, metconazole, myclobutanil, penconazole, propiconazole, prothioconazole, quinconazole, simeconazole, tebuconazole, tetraconazole, triadimefon, triadimenol, triticonazole, uniconazole, uniconazole-P, see also triazole fungicides)); copper fungicides (e.g., Bordeaux mixture, Burgundy mixture, Cheshunt mixture, copper acetate, copper carbonate, basic copper hydroxide, copper naphthenate, copper oleate, copper oxychloride, copper silicate, copper sulfate, copper sulfate, basic, copper zinc chromate, cufraneb, cuprobam, cuprous oxide, mancopper, oxine-copper, saisentong); cyanoacrylate fungicides (e.g., benzamacril, phenamacril); dicarboximide fungicides (e.g., famoxadone, fluoroimide); dichlorophenyl dicarboximide fungicides (e.g., chlozoline, dichlozoline, iprodione, isovalledione, myclozolin, procymidone, vinclozolin); phthalimide fungicides (e.g., captafol,

captan, ditalimfos, folpet, thiochlorfenphim); dinitrophenol fungicides (e.g., binapacryl, dinobuton, dinocap (e.g., dinocap-4, dinocap-6, meptyldinocap), dinoceton, dinopenton, dinosulfon, dinoterbon, DNOC); dithiocarbamate fungicides (e.g., amobam, asomate, azithiram, carbamorph, cufraneb, cuprobam, disulfiram, ferbam, metam, nabam, tecoram, thiram, urbacide, ziram); cyclic dithiocarbamate fungicides (e.g., dazomet, etem, milneb); polymeric dithiocarbamate fungicides (e.g., mancopper, mancozeb, maneb, metiram, polycarbamate, propineb, zineb); dithiolane fungicides (e.g., isoprothiolane, saijunmao); fumigant fungicides (e.g., dithioether, methyl bromide); hydrazide fungicides (e.g., benquinox, saijunmao); imidazole fungicides (e.g., cyazofamid, fenamidone, fenapanil, glyodin, iprodione, isovaledione, pefurazoate, triazoxide, see also conazole fungicides (imidazoles)); inorganic fungicides (e.g., potassium azide, potassium thiocyanate, sodium azide, sulfur, see also copper fungicides, see also inorganic mercury fungicides); mercury fungicides (e.g., inorganic mercury fungicides (e.g., mercuric chloride, mercuric oxide, mercurous chloride), organomercury fungicides (e.g., (3-ethoxypropyl)mercury bromide, ethylmercury acetate, ethylmercury bromide, ethylmercury chloride, ethylmercury 2,3-dihydroxypropyl mercaptide, ethylmercury phosphate, N-(ethylmercury)-ptoluenesulphonanilide, hydrargaphen, 2-methoxyethylmercury chloride, methylmercury benzoate, methylmercury dicyandiamide, methylmercury pentachlorophenoxide, 8-phenylmercurioxyquinoline, phenylmercuriurea, phenylmercury acetate, phenylmercury chloride, phenylmercury derivative of pyrocatechol, phenylmercury nitrate, phenylmercury salicylate, thiomersal, tolylmercury acetate)); morpholine fungicides (e.g., aldimorph, benzamorf, carbamorph, dimethomorph, dodemorph, fenpropimorph, flumorph, tridemorph); organophosphorus fungicides (e.g., ampropylfos, ditalimfos, EBP, edifenphos, fosetyl, hexylthiofos, inezin, iprobenfos, izopamfos, phosdiphen, pyrazophos, tolclofos-methyl, triamiphos); organotin fungicides (e.g., decafentin, fentin, tributyltin oxide); oxathiin fungicides (e.g., carboxin, oxycarboxin); oxazole fungicides (e.g., dichlozoline, dingjunezuo, drazoxolon, famoxadone, hymexazol, metazoxolon, myclozolin, oxadixyl, vinclozolin); polysulfide fungicides (e.g., barium polysulfide, calcium polysulfide, potassium polysulfide, sodium polysulfide); pyrazole fungicides (e.g., bixafen, fluxapyroxad, furametpyr, isopyrazam, penflufen, penthiopyrad, pyraclostrobin, pyrametostrobin, pyraoxystrobin, rabenzazole, sedaxane); pyridine fungicides (e.g., boscalid, buthiobate, dingjunezuo, dipyrithione, fluazinam, 10 fluopicolide, fluopyram, lvdingjunzhi, parinol, pyribencarb, pyridinitril, pyrifenox,

pyroxychlor, pyroxyfur); pyrimidine fungicides (e.g., bupirimate, diflumetorim, dimethirimol, ethirimol, fenarimol, ferimzone, nuarimol, triarimol); anilinopyrimidine fungicides (e.g., cyprodinil, mepanipyrim, pyrimethanil); pyrrole fungicides (e.g., dimetachlone, fenpiclonil, fludioxonil, fluoroimide); quinoline fungicides (e.g., ethoxyquin, halacrinat, 8-hydroxyquinoline sulfate, quinacetol, quinoxifen, tebufloquin); quinone fungicides (e.g., benquinox, chloranil, dichlone, dithianon); quinoxaline fungicides (e.g., chinomethionat, chlorquinox, thioquinox); thiazole fungicides (e.g., ethaboxam, etridiazole, isotianil, metsulfovax, othilinone, thiabendazole, thifluzamide); thiazolidine fungicides (e.g., flutianil, thiadifluor); thiocarbamate fungicides (e.g., methasulfocarb, prothiocarb); thiophene fungicides (e.g., ethaboxam, silthiofam); triazine fungicides (e.g., anilazine); triazole fungicides (e.g., amisulbrom, bitertanol, fluotrimazole, huanjunzuo, triazbutil, see also conazole fungicides (triazoles)); triazolopyrimidine fungicides (e.g., ametoctradin); urea fungicides (e.g., bentazon, pencycuron, quinazamid); unclassified fungicides (e.g., acibenzolar, acypetacs, allyl alcohol, benzalkonium chloride, bethoxazin, bromothalonil, chloropicrin, DBCP, dehydroacetic acid, diclomezine, diethyl pyrocarbonate, ethylcin, fenaminosulf, fenitropan, fenpropidin, formaldehyde, furfural, hexachlorobutadiene, methyl iodide, methyl isothiocyanate, nitrostyrene, nitrothal-isopropyl, OCH, 2-phenylphenol, phthalide, piperalin, propamidine, proquinazid, pyroquilon, sodium orthophenylphenoxide, spiroxamine, sultropen, thicyofen, tricyclazole, zinc naphthenate).

In some embodiments, the composition comprises 0.001% to 99.999% pesticide(s) (v/v). Commercially available pesticide products (e.g. Roundup®) contain the pesticide itself, typically referred to on the product label as one or more “active ingredients”, along with one or more “other ingredients”. The amount of “pesticide” in the compositions herein refers to the amount of the pesticide agent itself (i.e. the active ingredient(s)) present in the composition, absent any “other ingredients” that may be present. In some embodiments, the composition comprises 0.001% to 99%, 0.001% to 95%, 0.001% to 90%, 0.001% to 85%, 0.001% to 80%, 0.001% to 75%, 0.001% to 70%, 0.001% to 65%, 0.001% to 60%, 0.001% to 55%, 0.001% to 50%, 0.001% to 45%, 0.001% to 40%, 0.001% to 35%, 0.001% to 30%, 0.001% to 25%, 0.001% to 20%, 0.001% to 15%, 0.01% to 10%, 0.02% to 9%, 0.03% to 8%, 0.04 to 7%, 0.05% to 6%, 0.06% to 5%, 0.07% to 4%, 0.08% to 3%, 0.09 % to 2%, or 1-2% pesticide(s). In some embodiments, the composition comprises 0.001% to 10% pesticide. In

some embodiments, the composition comprises 0.001% to 10%, 0.005% to 9.75%, 0.01% to 9.5%, 0.015% to 9.25%, 0.02% to 9.0%, 0.025% to 8.75%, 0.03% to 8.5%, 0.035% to 8.25%, 0.04% to 8.0%, 0.045% to 7.75%, 0.05% to 7.5%, 0.055% to 7.25%, 0.06% to 7.0%, 0.065% to 6.9%, 0.07% to 6.8%, 0.075% to 6.7%, 0.08% to 6.6%, 0.085% to 6.5%, 0.09% to 6.4%, 0.095% to 6.3%, 0.1% to 6.2%, 0.15% to 6.1%, 0.2% to 6.0%, 0.25% to 5.9%, 0.3% to 5.8%, 0.35% to 5.7%, 0.4% to 5.6%, 0.45% to 5.5%, 0.5% to 5.4%, 0.55% to 5.3%, 0.6% to 5.2%, 0.65% to 5.1%, 0.7% to 5.0%, 0.75% to 4.9%, 0.8% to 4.8%, 0.85% to 4.7%, 0.9% to 4.6%, 0.95% to 4.5%, or 1% to 4% pesticide(s). In some embodiments, the composition comprises 0.625 to 3.5% (v/v) pesticide(s).

In some embodiments, the composition comprises 0.125-5% (v/v) of the combination of the polyacrylamide (e.g. the polyacrylamide microemulsion) and the crop protection enhancing adjuvant. In some embodiments, the composition comprises 0.5 to 1.25% (v/v) of the combination of polyacrylamide microemulsion and the crop protection enhancing adjuvant. In some embodiments, the composition comprises the polyacrylamide (e.g. polyacrylamide microemulsion) at a final concentration of 0.00125% to 1.25% (v/v).

In some embodiments, the composition comprises 91.5% to 99.25% (v/v) water. In some embodiments, the composition comprises 95.25% to 98.75% (v/v) water. In some embodiments, the composition comprises 91.5% to 99.25% (v/v) oil (e.g. 91.5% to 99.25% oil, 95.25% to 98.75% oil), as opposed to water. The weight ratio of pesticide(s) to microemulsion PAM is preferably in a range of 99:1 to 90:10, more preferably 97:3. For example, in some embodiments the weight ratio of pesticide(s) to microemulsion PAM is about 99:1, 98.5:1.5; 98:2, 97.5:2.5; 97:3, 96.5:3.5; 96:4, 95.5:4.5; 95:5, 94.5:5.5; 94:6; 93.5:6.5; 93:7; 92.5:7.5; 92:8; 91.5:8.5; 91:9, 90.5:9.5, or 90:10.

Other lipophilic pesticides may be used alone or in any combination with one another, and with or without clethodim. For example other herbicides include, but are not limited to: fenoxaprop; fluazifop; quizalofop; sethoxydim; chlorimuron; foramsulfuron; halosulfuron; iodosulfuron; nicosulfuron; primisulfuron; prosulfuron; rimsulfuron; thifensulfuron; tribenron; imazamox; imasaquin; imazethapyr; flumetsulam; cloransulam; clopyralid; fluroxypyr; diflufenzopyr; atrazine; simazine; metribuzin; bromoxynil; bentazon; linuron; isoxaflutole; mesotrione; tropamezone; acifluorfen; fomesafen; lactofen; flumiclorac; sulfentrazone; carfentrazone; ethalfluralin; pendimethalin; trifluralin; butylate; acetochlor; alachlor;

metolachlor; dimenthamid; flufenacet; dithiopyr. For example other fungicides include, but are not limited to: thiabendazole; iprodione; vinclozolin; imazilil; triforinc; fenarimol; bitertanol; cyproconazole; difenoconazole; fenbuconazole; flusilazole; ipconazole; metconazole; myclobutanil; propiconazole; prothioconazole; tebuconazole; tetraconazole; triadimefon; triadimenol; triticonazole; metalxyl; mefenoxam; cyprodinil; azoxystrobin; picoxystrobin; pyraclostrobin; etridiazole; fenhexamid; polyoxin; fluazinam; dimethomorph; acibenzolar-S-methyl; chlorothalonil; chloroneb; dicloran; quintozone (PCNB); famoxadone; fenamidone; mineral oils; organic oils.

The compositions may be formulated such that the microemulsion PAM is combined with a pesticide, such as in a tank mix. The formulation of the microemulsion PAM with pesticide may be further combined with crop protection enhancing adjuvant(s). Alternatively, the microemulsion PAM may be first combined with crop protection enhancing adjuvant(s), which can then be mixed with a pesticide, such as in a tank mix, prior to use.

It is also useful to formulate microemulsion PAM directly in-can with pesticides for use as a drift reducing agent. The in-can formulations may further contain additional crop protection enhancing adjuvant(s). Many lipophilic herbicides, fungicides, insecticides, and other types of pesticides are well known to decrease droplet size in spray applications, which leads to off-target movement or physical drift of a pesticide spray application. Often on pesticide labels, it is recommended by basic manufacturers of pesticides to use drift retardants so as to offset physical spray drift potential. Drift potential of pesticides, fertilizers, and crop protection enhancing adjuvants can be mitigated with the compositions described herein containing polyacrylamide, such as a polyacrylamide microemulsion.

In some aspects, provided herein are methods comprising contacting agricultural crops, turf and ornamental, or industrial vegetation management pests with the compositions described herein. In some embodiments, the contacting comprises spraying from a rotary atomizer. In some embodiments, the contacting comprises spraying from a rotary atomizer of a ground sprayer. In some embodiments, the contacting comprises spraying from a rotary atomizer of a UAV or other aerial spray equipment. In some embodiments, the UAV is a drone.

EXAMPLES

Example 1

Drone sprayer wind tunnel test

A drone sprayer was used, and spray droplet sizes were characterized using two different disk speeds for the rotary atomizer. A spray drone (XAG P40) was fixed to the ceiling of the agricultural drift tunnel (AgDT) and tested. For each test, the tanks were filled to the max fill line with the spray mixture. Spray mixtures with and without a drift reducing agent (DRA) were tested. All tests were performed with the atomizers at 4 feet from the ground. Droplets were measured using a Malvern Spraytec droplet size analyzer. The median droplet size (DV50) and % of the spray solution less than 141 micrometers was measured to evaluate droplet size and drift potential. Results are shown in FIG. 1 and FIG. 2.

Three different oil emulsion adjuvants, emulsion DRT1, emulsion DRT2, and emulsion DRT3, were tested, along with a polyacrylamide adjuvant (PAM DRA 1). As shown in the figures, oil emulsion adjuvants decreased DV50 and increased driftable fine particles with Veltyma™ fungicide and Shredder™ 2,4-D LV4 herbicide tank mixes. In contrast, solution polyacrylamide adjuvants (PAM DRA 1) increased DV50 and decreased driftable fine particles with Veltyma™ fungicide and Shredder™ 2,4-D LV4 herbicide tank mixes. Taken together, these results show that polyacrylamide-containing solutions reduce drift from rotary atomizer nozzles. Accordingly, polyacrylamide-containing compositions as described herein find use as additions to pesticides, fertilizers and the like, including oil emulsion adjuvants, to create stable oil-emulsion formulations containing polyacrylamide, and these formulations find use to reduce drift potential when applied using a rotary atomizer, including with UAV applications.

Example 2

Field spray deposition study

A field spray deposition study was conducted on V10 stage corn. Spray applications were conducted using a DJI AGRAS T40 drone outfitted with rotary atomizer nozzles set to deliver a medium (226-325 micron) droplet size. The drone sprayed 2 gallons of spray carrier water per acre at 12 ft above the canopy height. Treatments were replicated three times, and included

water, an oil-emulsion adjuvant (0.5% v/v concentration), and an oil-emulsion + polyacrylamide (PAM) adjuvant (0.5% v/v). The wind direction was perpendicular to the drone's flight path, resulting in varying degrees of swath shift downwind from the drone's flight path. The wind direction was between 1 to 3 knots.

5 A single pass of each spray application was made, and water-sensitive cards (SpotOn, Innoquest, Inc.) were used to evaluate droplet deposition in the spray swath, and drift downwind from the spray swath. The water sensitive cards were mounted on poles positioned at the following offsets from the drone's flight path (negative number indicates upwind from drone position, positive number indicates downwind from drone position): -4, 4, 12, 20, 28, 36, 44, and
10 56 ft. Cards were analyzed using digital image analysis software (DropScope, SprayX) to measure the % coverage, quantity of droplets, and density of droplets on each card. Results are shown in FIGS. 3-7.

The overall droplet distribution across the collection area shows that water alone experienced a shift in the spray swath, resulting in more droplets collected from 12+ feet
15 downwind from the drone's flight position (Fig. 3-4). Both adjuvants reduced the shift in swath deposition from wind, but the emulsion DRT + PAM had a greater effect than the emulsion DRT. Within the spray swath, the emulsion DRT resulted in minimal to no change in the number of droplets recovered, and a slight reduction in % covered area on the water-sensitive cards (Fig. 5A-B). The emulsion DRT + PAM increased the number of droplets recovered and
20 droplet density and resulted in higher % covered area within the spray swath. From 28 to 56 ft downwind from the drone's flight path, both adjuvants reduced the number of droplets recovered and reduced the % coverage on cards (Fig 6A-B). However, at the furthest position of 56 ft from the flight path, the emulsion DRT resulted in a greater number of droplets while the emulsion DRT + PAM significantly decreased the number of droplets (Fig. 7). Taken together, these
25 findings indicate that the emulsion DRT + PAM adjuvant reduced drift more effectively and improved droplet deposition compared to the emulsion DRT adjuvant.

EXAMPLE 3

Field spray deposition study

A field spray deposition study was conducted on bare ground. Spray applications were conducted using a DJI AGRAS T40 drone outfitted with rotary atomizer nozzles set to deliver a medium (226-325 micron) droplet size. The drone sprayed 2 gallons of spray carrier water per acre from 12 ft above the ground height. Treatments were replicated five times, and included water, two different oil-emulsion adjuvants (DRT1 and DRT2; both at 2 oz/ac), and an oil-emulsion + polyacrylamide (PAM) adjuvant (PAM DRA2; 2 oz/ac). The wind direction was perpendicular to the drone's flight path, resulting in varying degrees of swath shift downwind from the drone's flight path.

A single pass of each spray application was made, and water-sensitive cards were used to evaluate droplet deposition in the spray swath, and drift downwind from the spray swath. The water sensitive cards were mounted on stakes positioned upwind, in the spray swath, and downwind from the spray swath. Cards were analyzed using digital image analysis to measure the % coverage of the spray solution on each card.

The oil-emulsion adjuvants both resulted in a lower spray coverage within the swath vs. water alone (FIG. 8). The oil-emulsion + PAM adjuvant PAM DRA2 resulted in greater spray coverage within the swath vs. water alone (FIG. 8). This difference in coverage indicates that the spray droplets in oil-emulsion adjuvants may have drifted from the spray swath area and not reached their intended target within the spray swath. By contrast, the oil-emulsion + polyacrylamide adjuvant PAM DRA2 reduced off-target droplet movement and improved coverage in the spray swath.

Example 4

Field spray deposition study

A field spray deposition study was conducted on bare ground. Spray applications were conducted using a DJI AGRAS T40 drone outfitted with rotary atomizer nozzles set to deliver a medium (226-325 micron) droplet size. The drone sprayed 2 gallons of spray carrier water per acre from 12 ft above the ground. Treatments included sulfentrazone, sulfentrazone + oil-emulsion adjuvant DRT4 (2 oz/ac), and the oil-emulsion + polyacrylamide (PAM) adjuvant PAM DRA3 (2 oz/ac). The wind direction was perpendicular to the drone's flight path, resulting

in a swath displacement downwind from the drone's flight path. A single pass of each spray application was evaluated, and a Swath Gobbler was used to measure spray coverage by analyzing the distribution of droplets on a strip of paper across the 60 ft plot area.

The oil-emulsion adjuvant had minimal effect on max % coverage and mean % coverage, and reduced the area under the spray coverage progress curve (FIG. 9). The oil-emulsion + PAM PAM DRA3 reduced the swath width, increased the max and mean % coverage, and increased the area under the coverage progress curve (FIG. 9). These findings indicate that the oil-emulsion + PAM treatment reduced movement of spray droplets and improved spray coverage vs. a standard oil-emulsion adjuvant.

CLAIMS

We claim:

1. A composition comprising:

- a) at least one of a pesticide and a crop protection enhancing adjuvant; and
- 5 b) a polyacrylamide;

wherein the composition is formulated such that it produces particles when released from a rotary atomizer, and wherein:

- i. said particles have an average diameter that is larger than the average diameter of particles produced by a composition lacking the polyacrylamide; and/or
- 10 ii. a driftable fraction of said particles is less than a driftable fraction of particles produced by a composition lacking the polyacrylamide.

2. The composition of claim 1, wherein the polyacrylamide comprises a polyacrylamide microemulsion.

15

3. The composition of claim 1 or claim 2, wherein the polyacrylamide microemulsion is an inverse microemulsion.

4. The composition of any one of claims 1-3, wherein the polyacrylamide microemulsion is a transparent/semitransparent inverse microlattice polyacrylamide.

20 5. The composition of any of claims 1-4, wherein the polyacrylamide microemulsion comprises polyacrylamide having less than 30 mole percent anionic charge.

6. The composition of any of claims 1-4, wherein the polyacrylamide microemulsion comprises polyacrylamide having 0-22 mole percent anionic charge.

25 7. The composition of any of claims 1-4, wherein the polyacrylamide microemulsion comprises polyacrylamide having 3-18 mole percent anionic charge.

8. The composition of any of claims 1-4, wherein the polyacrylamide microemulsion comprises polyacrylamide having 7-15 mole percent anionic charge.

9. The composition of any of claims 1-4, wherein the polyacrylamide microemulsion comprises polyacrylamide having 15-22 mole percent anionic charge.
10. The composition of any one of claims 1-9, wherein the crop protection enhancing adjuvant is selected from the group consisting of: crop oil concentrates, modified vegetable oils, drift
5 retardants, soil or foliage penetrants, buffering agents, wetting agents, surfactants, nitrogen fertilizers, compatibility agents, defoamers, deposition agents, or combinations thereof.
11. The composition of any of claims 1-10, wherein the crop protection enhancing adjuvant is a lipophilic adjuvant.
12. The composition of any one of claims 1-11, wherein the pesticide comprises an insecticide, a
10 herbicide, a bactericide, a fungicide, a larvicide, or a combination thereof.
13. The composition of any one of claims 1-12, wherein the pesticide comprises a lipophilic pesticide.
14. The composition of any of claims 1-13, wherein the composition comprises 0.625-3.5% (v/v) pesticide.
15. The composition of any of claims 1-14, wherein the weight ratio of pesticide to
15 polyacrylamide microemulsion is in a range of 99:1 to 90:10.
16. The composition of claim 15, wherein the weight ratio of pesticide to polyacrylamide microemulsion is 97:3.
17. The composition of any of claims 1-16, wherein the composition comprises a pesticide and
20 0.125-5% (v/v) of a combination of the polyacrylamide microemulsion and the crop protection enhancing adjuvant.
18. A method comprising contacting agricultural crops, turf and ornamental, or industrial vegetation management pests with a composition of any of claims 1-17.
19. The method of claim 18, wherein the contacting comprises spraying from a rotary atomizer.

20. The method of claim 19, wherein the contacting comprises spraying from a rotary atomizer of an unmanned aerial vehicle (UAV), such as a drone.

5 21. A method comprising: delivering a pesticide formulation to a plant or soil via a rotary atomizer, wherein said pesticide formulation comprises at least one pesticide, a crop protection enhancing adjuvant, and a polyacrylamide.

Veltyma

12,000 RPM disk speed

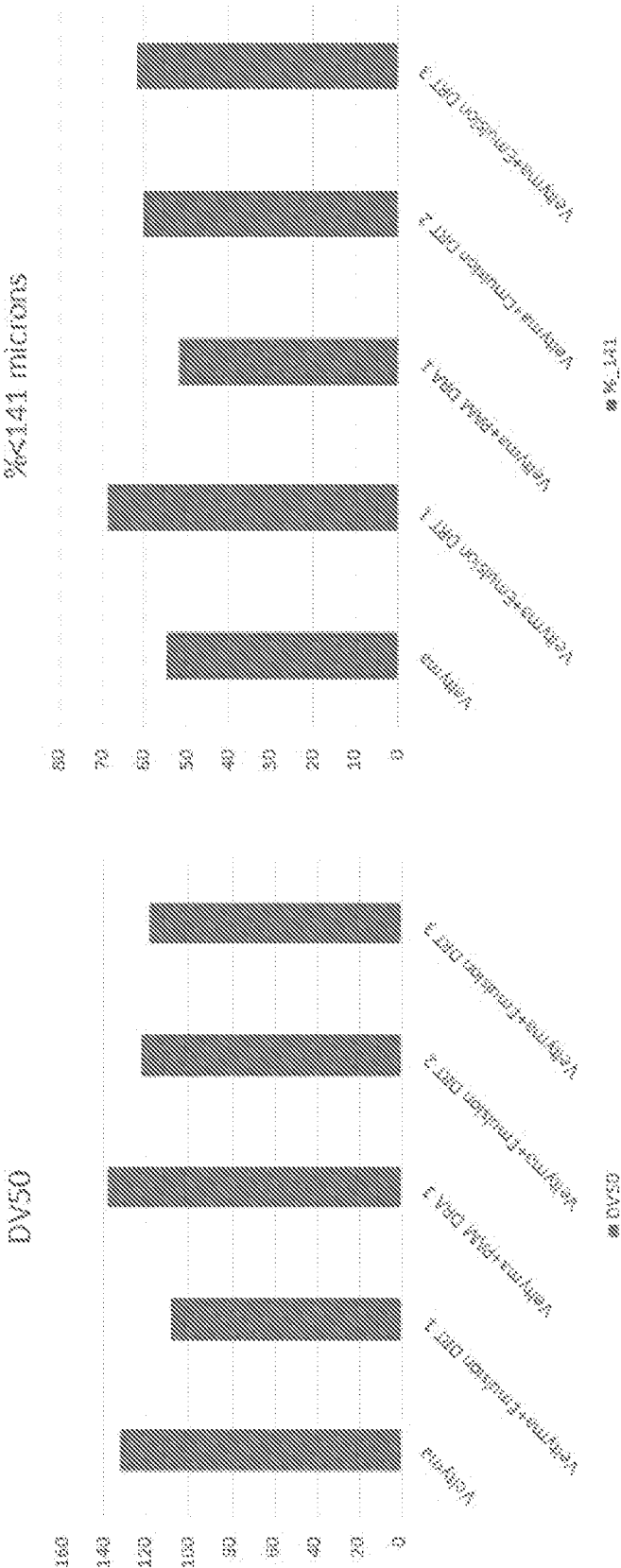


FIG. 1A

FIG. 1B

Shredder 2,4-D LV4

12,000 RPM disk speed

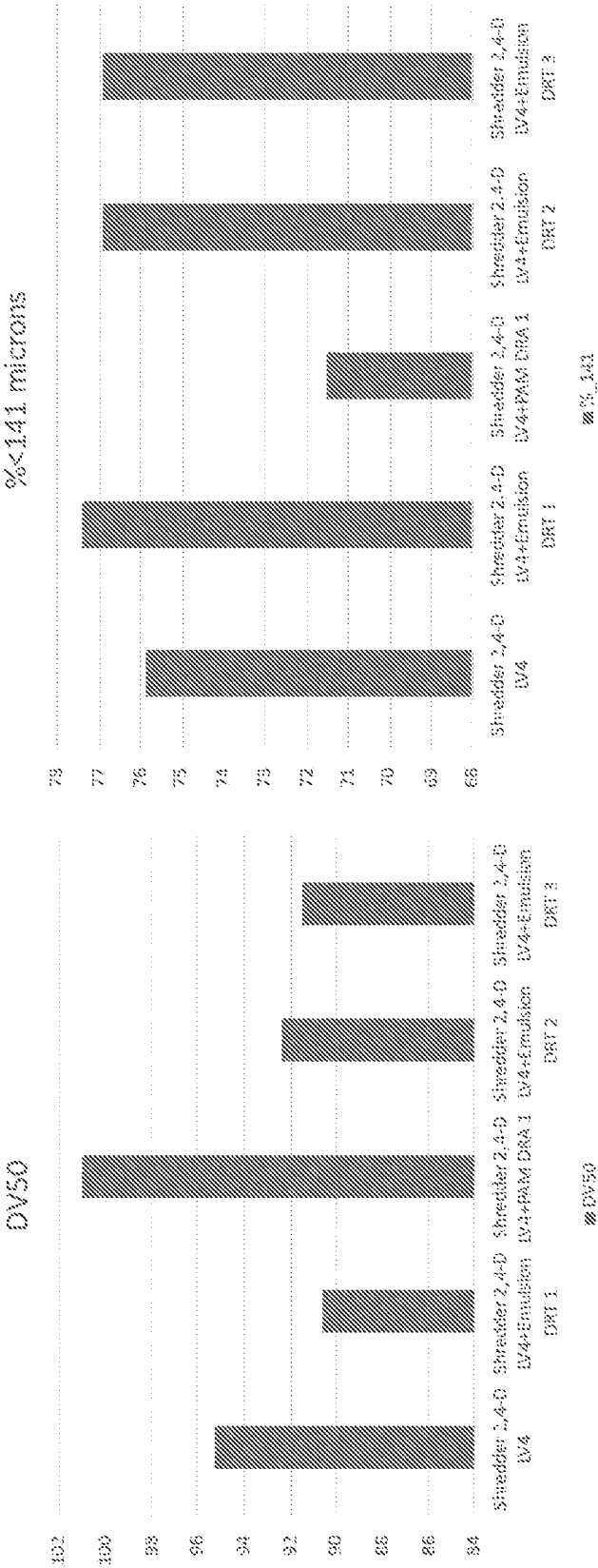


FIG. 2B

FIG. 2A

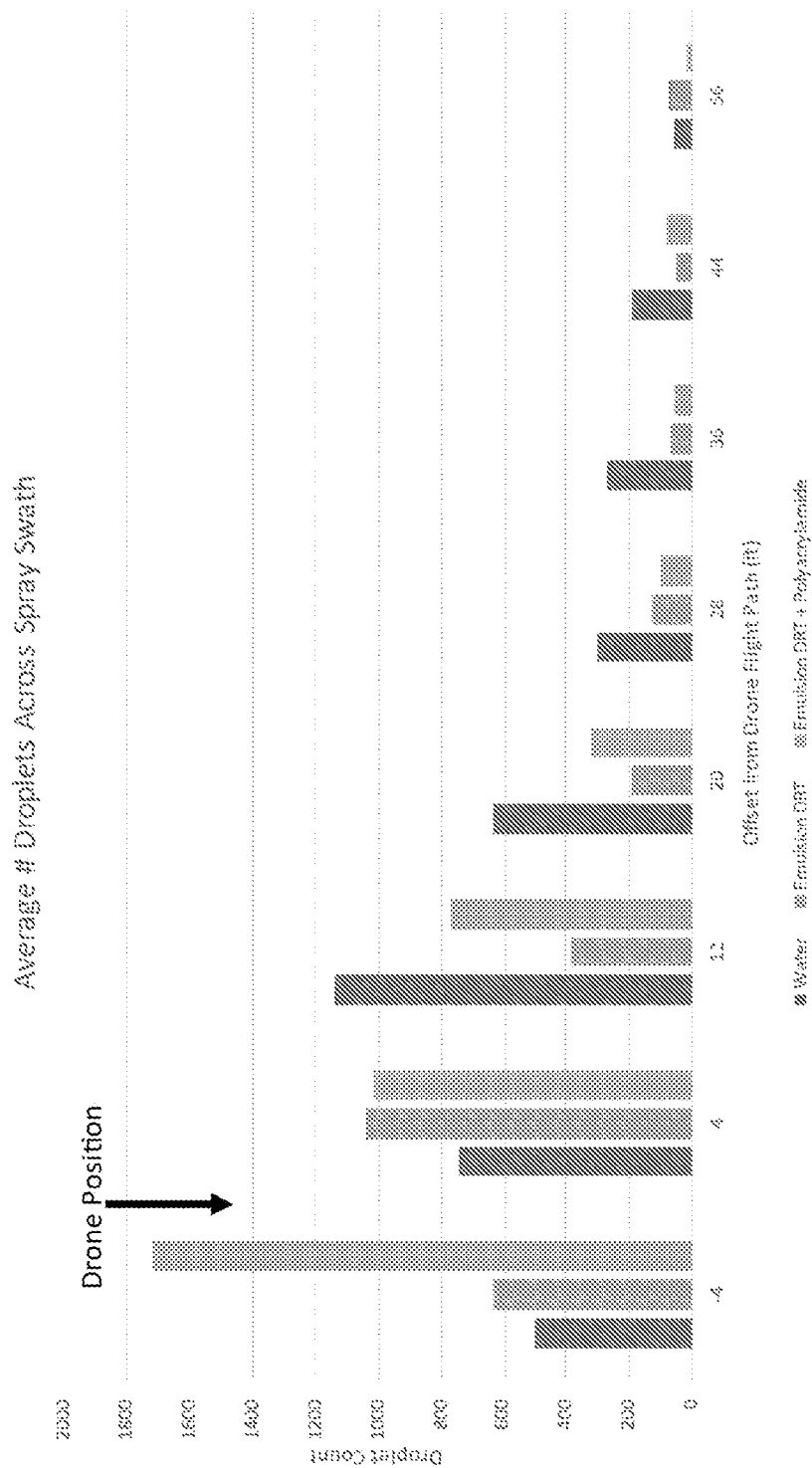


FIG. 3

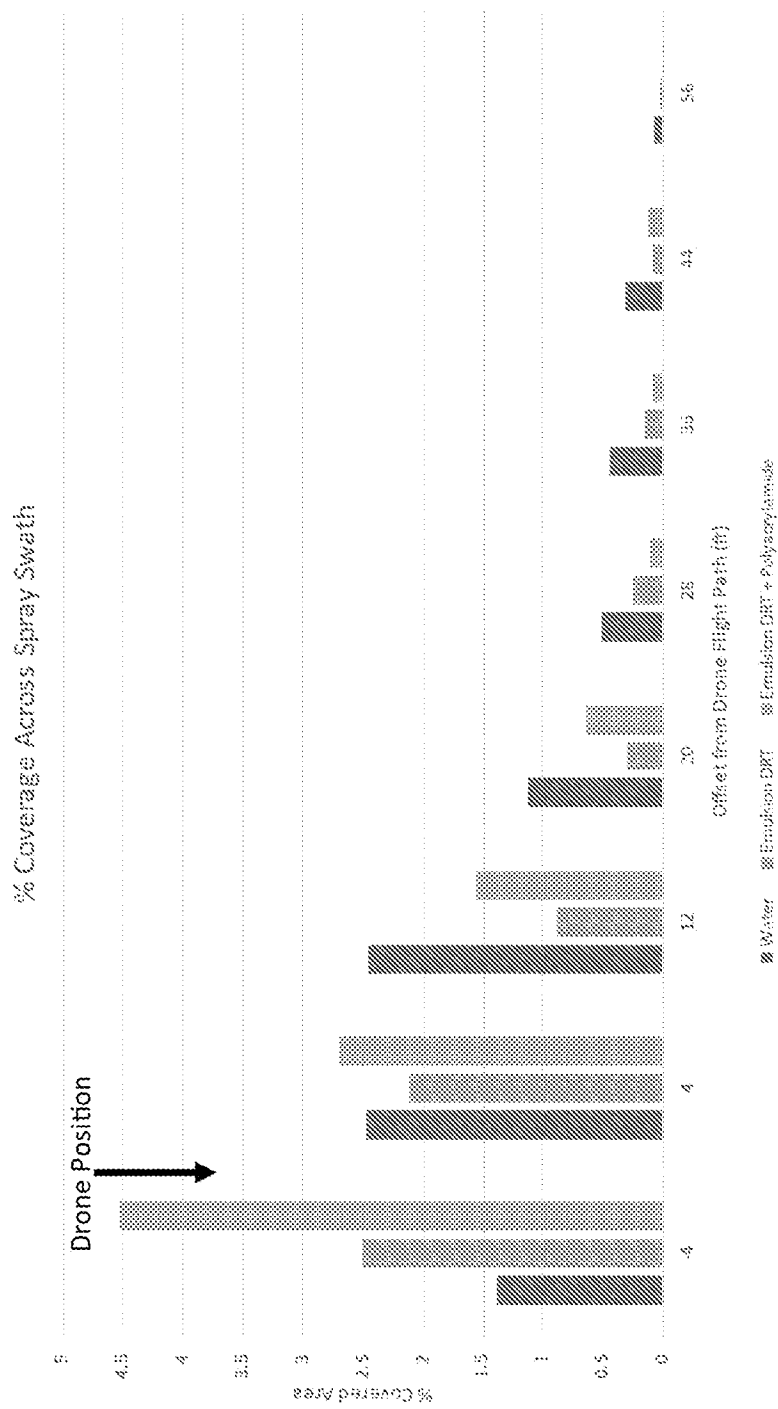


FIG. 4

Spray Swath Droplet Deposition

Averaged across collection locations under spray swath

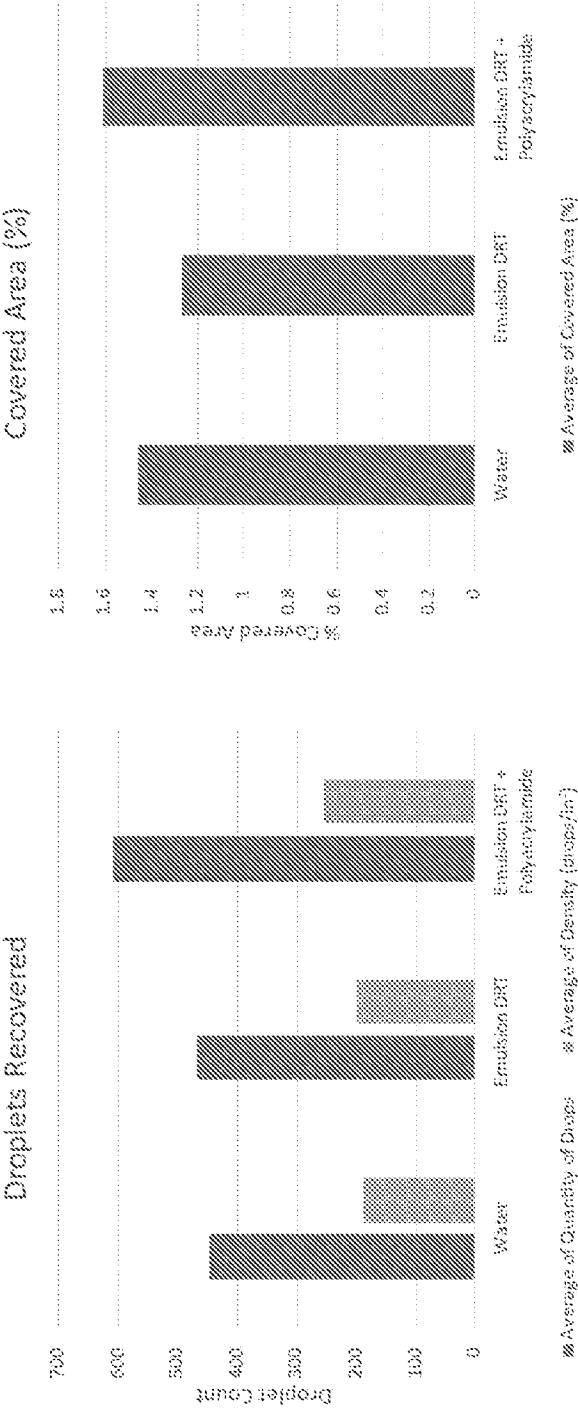


Fig. 5A

Fig. 5B

Downwind Droplet Deposition

Averaged from 28 to 56 ft downwind from drone flight path

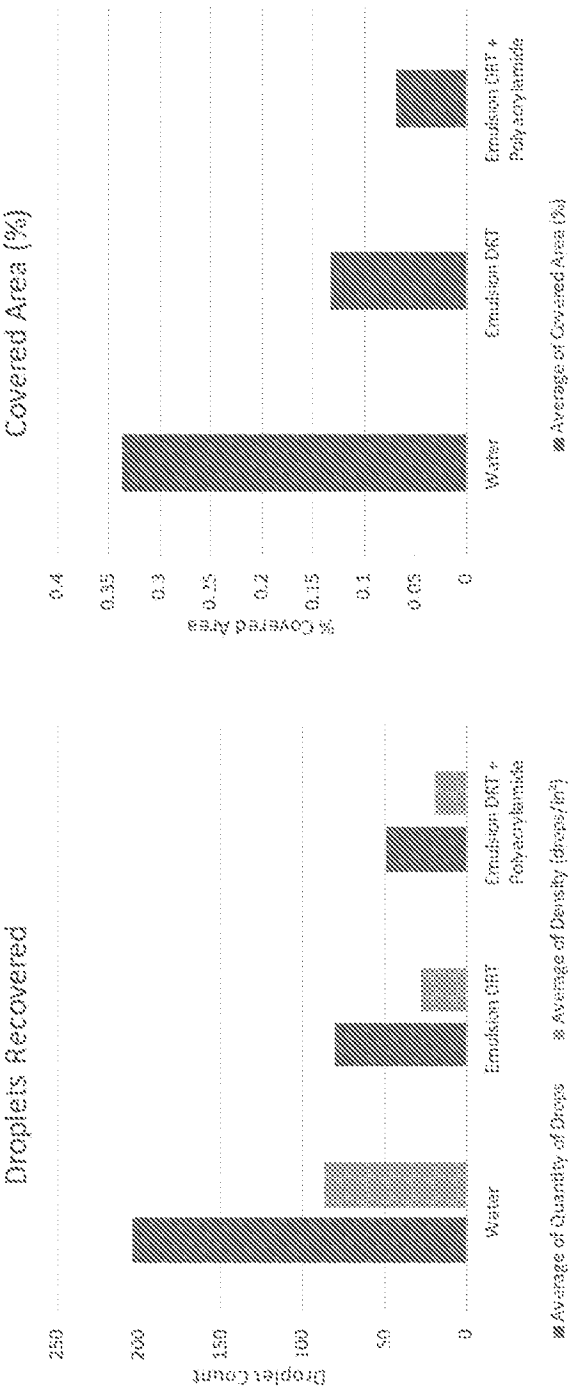


Fig. 6A

Fig. 6B

Downwind Droplet Deposition

56 ft downwind from drone flight path

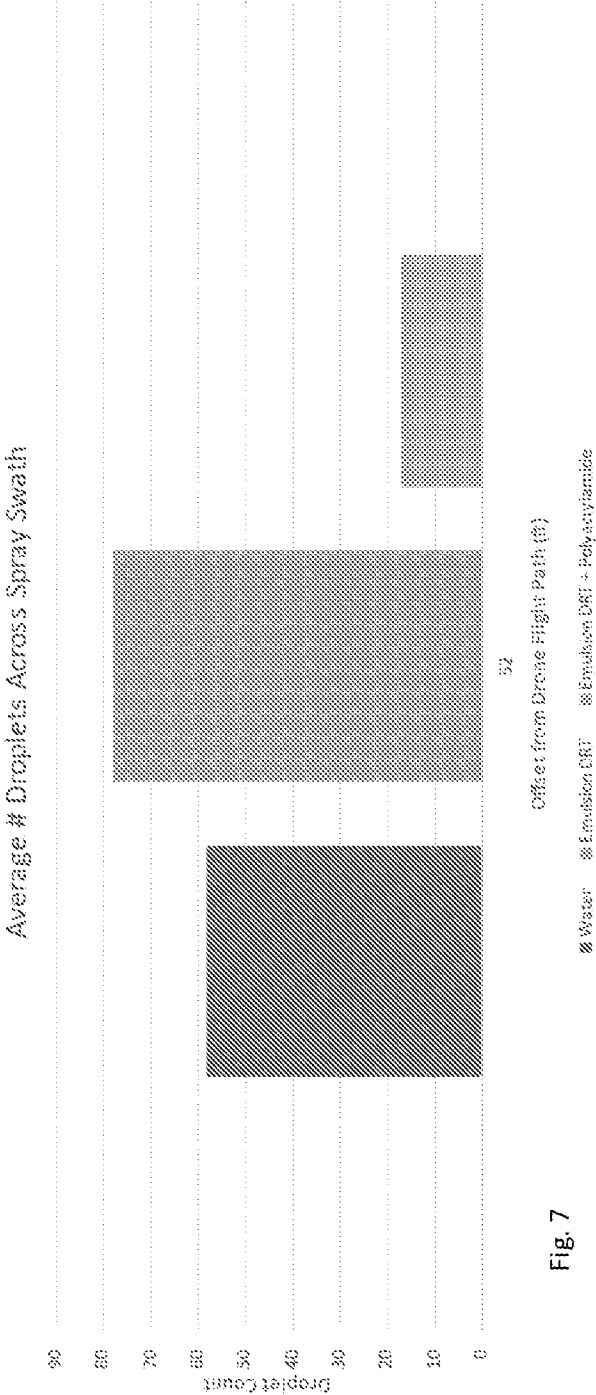
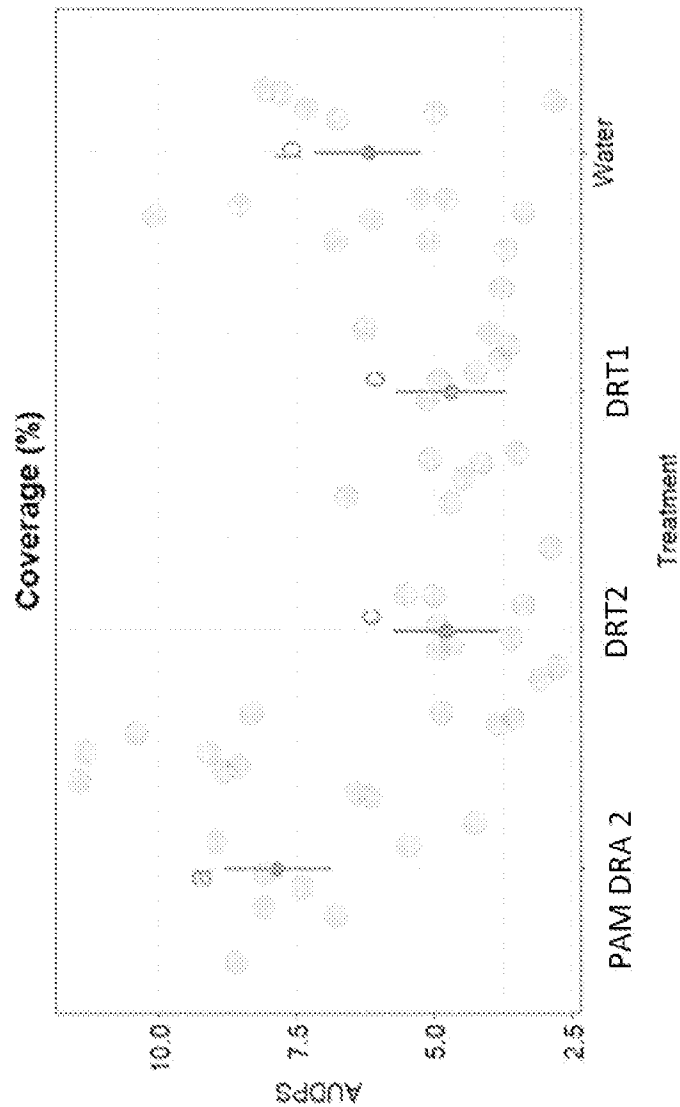


Fig. 7

FIG. 7



Treatment	Mean	SE	Lower CL	Upper CL
PAM DRA 2	7.84	0.8	6.87	8.8
DRT2	4.77	0.49	3.8	5.73
DRT1	4.69	0.48	3.7	5.69
Water	6.2	0.49	5.24	7.15

FIG. 8

Herbicide	Adjuvant	Swath Width (ft)	Max % Coverage	Mean % Coverage	Area Under Coverage Progress Curve
Sulfentrazone	-	24.7	8.1	2.8	69.3
Sulfentrazone	DRT4	22.0	8.7	2.3	50.6
Sulfentrazone	PAM DRA3	14.9	24.9	13.3	204.5

FIG. 9