

**Novel Non-Coding Heterocyclic Amino Acids (NCHAA) and Their
Use as Herbicides**

FIELD OF THE INVENTION

The invention relates to novel chemical compounds having
5 herbicidal activity, process for their manufacture and their use
in crop protection.

BACKGROUND OF THE INVENTION

Fidelity of protein synthesis is critically important as it
ensures functional activity of cell proteins. However, some non-
10 coded amino acids, despite not being encoded by the genetic
code, are nevertheless found in proteins. Error rates of
translation in vivo have been estimated to be on the order of
 10^{-3} - 10^{-4} . However, high synthesis rates impose constraints on
accuracy that lead to an increased the number of erroneous
15 cellular proteins. As such, nascent proteins in rapidly growing
organs such as plants meristems in germinating and early
developing periods are more prone to misincorporation amino
acids.

Incorporation of non-coded amino acids in the peptide chain can
20 make proteins dysfunctional or toxic. It was further suggested
that herbicidal activity of natural non-coded amino acid meta-
tyrosine and some of its derivatives relates to its
incorporation in plant proteins Bertin et al., 2007b;
WO2017141253.

25 New compounds effective for controlling the growth of undesired
vegetation are in constant demand. In the most common situation,
such compounds are sought to selectively control the growth of
weeds in useful crops such as cotton, rice, corn, wheat and
soybeans, to name a few. Unchecked weed growth in such crops can
30 cause significant losses, reducing profit to the farmer and
increasing costs to the consumer. In other situations,
herbicides are desired which will control all plant growth.

Examples of areas in which complete control of all vegetation is desired are areas around railroad tracks, storage tanks and industrial storage areas. Identifying new compounds having herbicidal activity which are more effective, less costly and environmentally safe remains long and unmet need.

SUMMARY OF THE INVENTION

It is a principal object of the present invention to provide novel, non-coded amino acids as potent herbicides.

The invention provides a compound having the structure



or a salt thereof, wherein:

A is five, six or nine-membered ring comprising one or more heteroatoms; wherein each of the heteroatoms is independently selected from the group consisting of N, S, and O; and wherein one or more of the carbon atoms of the ring is optionally substituted with R₃, R₄, R₆ and R₇; and wherein each of R₃, R₄, R₆ or R₇ is independently selected from and an electron withdrawing group (EWG) or an electron donating group (EDG); wherein when R₃, R₄, R₆ or R₇ is EDG, at least one carbon of the ring is substituted with EWG; and, wherein when the heteroatoms of the ring are N or S, each independently is optionally substituted with R₃, R₄, R₆ and R₇;

T is selected from the group consisting of , sulfonyl, ammonium, alkylamine; arylamine, phosphonium, nitro, cyano, dihalomethyl, acyl, formyl, haloformyls, carboxyl, alkoxy carbonyl, and aminocarbonyl;

n is 0 or 1;

y is 0 to 8;

X is



wherein R₁ is selected from the group consisting of carboxyl group, carbamoyl group, ester with saturated or non-saturated alcohols with straight, branched, cyclic chain or aromatic chain, ethylene glycol, polyethylene glycol, propylene glycol, polypropylene glycol, carboxamide substituted with straight, branched, cyclic aliphatic chain, cyclic aromatic chain, ethylene glycol, polyethylene glycol, propylene glycol, polypropylene glycol, sulfonamide, and phosphoramidate; and
 5 wherein R₂ is selected from the group consisting of optionally substituted primary amine, secondary amine, tertiary amine, carboxamide, sulfonamide, and phosphoramidate.

The invention further provides an agricultural composition comprising the compound having the structure



or a salt thereof, wherein:

A is five, six or nine-membered ring comprising one or more heteroatoms; wherein each of the heteroatoms is independently selected from the group consisting of N, S, and O; and wherein
 20 one or more of the carbon atoms of the ring is optionally substituted with R₃, R₄, R₆ and R₇; and wherein each of R₃, R₄, R₆ or R₇ is independently selected from and an electron withdrawing group (EWG) or an electron donating group (EDG); wherein when R₃, R₄, R₆ or R₇ is EDG, at least one carbon of the
 25 ring is substituted with EWG; and, wherein, when one or more heteroatoms of the ring is N or S, each independently is optionally substituted with R₃, R₄, R₆ and R₇;

T is selected from the group consisting of, sulfonyl, ammonium, alkylamine; arylamine, phosphonium, , nitro, cyano,

dihalomethyl, acyl, formyl, haloformyls, carboxyl, alkoxy carbonyl, and aminocarbonyl;

n is 0 or 1;

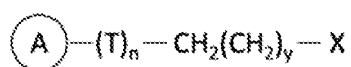
y is 0 to 8;

5 X is



wherein R₁ is selected from the group consisting of carboxyl group, carbamoyl group, ester with saturated or non-saturated alcohols straight, branched, cyclic chain or aromatic chain, ethylene glycol, polyethylene glycol, propylene glycol, polypropylene glycol, carboxamide substituted with straight, branched, cyclic aliphatic chain, cyclic aromatic chain, ethylene glycol, polyethylene glycol, propylene glycol, polypropylene glycol, sulfonamide, and phosphoramidate; and
 10
 15 wherein R₂ is selected from the group consisting of optionally substituted primary amine, secondary amine, tertiary amine, carboxamide, sulfonamide, and phosphoramidate, and at least one agriculturally acceptable carrier.

The invention provides a method of controlling undesired plant growth, comprising applying to the locus of the undesired plant growth a herbicidally effective amount of a compound having the structure
 20



25 or a salt thereof, wherein:

A is five, six or nine-membered ring comprising one or more heteroatoms; wherein each of the heteroatoms is independently selected from the group consisting of N, S, and O; and wherein one or more of the carbon atoms of the ring are optionally

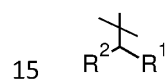
substituted with R₃, R₄, R₆ and R₇; and wherein each of R₃, R₄, R₆ or R₇ is independently selected from an electron withdrawing groups (EWG) or an electron donating groups (EDG); wherein when R₃, R₄, R₆ or R₇ is EDG, at least one carbon of the ring is substituted with EWG; and wherein, when one or more heteroatoms of the ring is N or S, each independently is optionally substituted with R₃, R₄, R₆ and R₇;

T is selected from the group consisting of sulfonyl, ammonium, alkylamines and arylamines, phosphonium, nitro, cyano, dihalomethyl, acyl, formyl, haloformyls, carboxyl, alkoxy carbonyl, and aminocarbonyl;

n is 0 or 1;

y is 0 to 8;

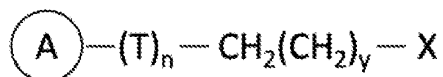
X is



wherein R₁ is selected from the group consisting of carboxyl group, carbamoyl group, ester with saturated or non-saturated aliphatic straight, branched, cyclic chain, or aromatic chain, ethylene glycol, polyethylene glycol, propylene glycol, polypropylene glycol, carboxamide substituted with straight, branched, cyclic aliphatic or aromatic chain, ethylene glycol, polyethylene glycol, propylene glycol, polypropylene glycol, sulfonamide; and phosphoramidate; and wherein R₂ is selected from the group consisting of optionally substituted primary amine, secondary amine, tertiary amine, carboxamides, sulfonamide, and phosphoramidate.

The invention further provides a method of controlling undesired plant growth comprising applying to the locus of the undesired plant growth:

30 a. A first herbicide having the structure



or a salt thereof, wherein:

5 A is five, six or nine-membered ring comprising one or more heteroatoms; wherein each of the heteroatoms is independently selected from the group consisting of N, S, and O; and wherein one or more of the carbon atoms of the ring are optionally substituted with R₃, R₄, R₆ and R₇; and
 10 wherein each of R₃, R₄, R₆ or R₇ is independently selected from and an electron withdrawing group (EWG) or an electron donating group (EDG); wherein when R₃, R₄, R₆ or R₇ is EDG, at least one carbon of the ring is substituted with EWG; and wherein, when one or more heteroatoms of the ring is N or S, each independently is optionally substituted with R₃, R₄,
 15 R₆ and R₇;

T is selected from the group consisting of sulfonyl, ammonium, alkylamine; arylamine, phosphonium, nitro, cyano, dihalomethyl, acyl, formyl, haloformyls, carboxyl, alkoxy carbonyl, and aminocarbonyl;

20 n is 0 or 1;

y is 0 to 8;

X is



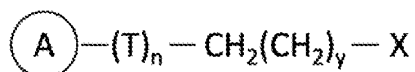
25 wherein R₁ is selected from the group consisting of carboxyl group, carbamoyl group, ester with saturated or non-saturated aliphatic straight, branched or cyclic chain, ethylene glycol, polyethylene glycol, propylene glycol, polypropylene glycol; and wherein R₂ is selected from the group consisting of optionally substituted primary amine;
 30 secondary amine; tertiary amine; and an amide derivative of carboxylic or inorganic acid; and

- b. A second herbicide, to effectively control the undesired plant growth.

DETAILED DESCRIPTION OF THE INVENTION

The present invention is now described more fully hereinafter with reference to the accompanying examples, in which embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather these embodiments are provided so that this disclosure will be thorough and complete and will fully convey the scope of the invention to those skilled in the art.

In one embodiment, the invention provides a compound having the structure



- or a salt thereof, wherein:

A is five, six or nine-membered ring comprising one or more heteroatoms; wherein each of the heteroatoms is independently selected from the group consisting of N, S, and O; and wherein one or more of the carbon atoms of the ring is optionally substituted with R₃, R₄, R₆ and R₇; and wherein each of R₃, R₄, R₆ or R₇ is independently selected from an electron withdrawing group (EWG) or an electron donating group (EDG); wherein when R₃, R₄, R₆ or R₇ is EDG, at least one carbon of the ring is substituted with EWG; and wherein, when one or more heteroatoms of the ring is N or S, each independently is optionally substituted with R₃, R₄, R₆ and R₇;

T is selected from the group consisting of sulfonyl, ammonium, alkylamine; arylamine, phosphonium, nitro, cyano, dihalomethyl, acyl, formyl, haloformyls, carboxyl, alkoxycarbonyl, and aminocarbonyl;

n is 0 or 1;

y is 0 to 8;

X is

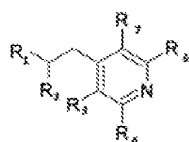


- 5 wherein R₁ is selected from the group consisting of carboxyl group, carbamoyl group, ester with saturated or non-saturated alcohols straight, branched, cyclic chain or aromatic chain, ethylene glycol, polyethylene glycol, propylene glycol, polypropylene glycol, carboxamide substituted with straight, branched, cyclic aliphatic chain, cyclic aromatic chain, ethylene glycol, polyethylene glycol, propylene glycol, polypropylene glycol, sulfonamide, and phosphoramidate; and
- 10 wherein R₂ is selected from the group consisting of optionally substituted primary amine, secondary amine, tertiary amine, carboxamide, sulfonamide, and phosphoramidate. In one embodiment, A is selected from the group consisting of pyrrole, pyrazole, imidazole, triazole, thiophene, dithiole, trithiole, thiazole, dithiazole, trithiazolidine, thiadiazole, dithiadiazole, thiatriazole, oxazole, furan, oxathiole, pyridine, pyridazine, pyrimidine, pyrazine, triazine, thiazine, dithiazine, thiadiazine, 2H-1,3,4,5-thiatriazine, dithiadiazine, pyrrolopyridine, pyrrolopyrimidine, pyrrolotriazine, thiopyranopyrrole, pyrrolothiazine, pyrrolodithiazine, and thienopyridine. In yet another embodiment, A is selected from
- 25 the group consisting of thiophene, 2H-1,3-dithiole, 3H-1,2-dithiole, 1H-pyrrole, 2H-1,2,3-triazole, 1H-1,2,4-triazole, 1,3-thiazole, 1,2,5-thiadiazole, 1,2,4-thiadiazole, 1,3-oxazole, furan, and pyridine. In one embodiment, the EWG is selected from the group consisting of triflyl (trifluoromethanesulfonyl), trihalide, cyano, sulfonate, nitro, ammonium, quaternary amine, aldehyde, ketone, carboxylic acid, ester, amide, and halide. As used herein, the term "electron
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withdrawing group" (EWG) refers, without limitation, to an atom or a group that draws electron density from neighboring atoms or aromatic ring, usually by resonance or inductive effects. As used herein, the term "electron donating group" (EDG) refers, without limitation, to an atom or a group that donates electron density to neighboring atoms or aromatic ring, usually by resonance or inductive effects. In one embodiment, the EDG is selected from the group consisting of phenoxide, tertiary amine, secondary amine, primary amine, ether, alkyl, phenyl and vinyl.

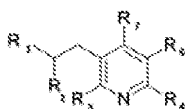
In yet further embodiment, R₂ is primary, secondary and tertiary amine substituted with a group selected from hydrogen, an aliphatic compound with straight or branched chain, an aliphatic compound with non-aromatic ring, straight or branched-chain alcohol, alcohol with non-aromatic ring, phosphoric acid, phosphonic acid, terminal carbon of phosphonate, ethylene glycol, polyethylene glycol, propylene glycol and polypropylene glycol. In another embodiment, R₂ is selected from the group consisting of carboxamide with saturated or non-saturated straight, branched or cyclic chain, sulfonamide, and phosphoramidate.

In one embodiment the invention provides a compound having the structure:



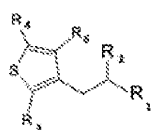
wherein R₁ is COOH, COOCH₃, COOC₂H₅, COOC₃H₇; R₂ is NH₂; R₃ and R₇ are independently selected from H, CF₃, CCl₃, Cl, and F; and R₄ and R₆ are independently selected from H, Cl, and Br.

In another embodiment, the invention provides a compound having the structure:

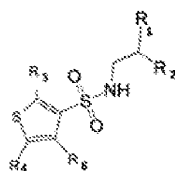


- wherein R₁ is selected from COOH, COOCH₃, COOC₂H₅, and COOC₃H₇; R₂ is NH₂; R₃ and R₄ are independently selected from H, Br and Cl; and R₆ and R₇ are independently selected from H, Cl, NO₂, CF₃, and CCl₃.

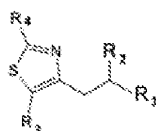
In yet another embodiment, the invention provides a compound having the structure:



- wherein R₁ is selected from COOH, COOCH₃, COOC₂H₅, COOC₄H₉, CONHCH₂COOH, and COO(CH₂)₃CH₃; R₂ is selected from NH₂, NHCOCH₃, NHCO, and NH(CH₂)₂O(CH₂)₂OH; R₃ and R₄ are independently selected from H, Cl, Br, CN, CHF₂, CF₃, CCl₃; and R₆ is H or CF₃. In one embodiment, the invention provides a compound having the structure:

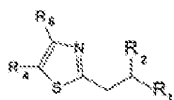


- wherein R₁ is selected from COOH, COOCH₃, COOC₂H₅, COOC₅H₁₁, and COO(CH₂)₂(CH₂)₂CH₃; R₂ is NH₂; R₃ and R₄ are independently selected from H, Br, and Cl; and R₆ is selected from H, F, Cl, Br, CF₃, CCl₃.
- In one embodiment, the invention provides a compound having the structure:



wherein R₁ is selected from COOH, COOCH₃, COOC₂H₅, COOC₅H₁₁, and COO(CH₂)₂(CH₂)₂CH₃; R₂ is selected from NH₂, NHC(O)CH₃, or NHC(O)C₂H₅; R₃ and R₄ are each independently selected from H, Br, Cl, and NH₂.

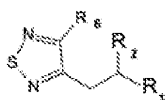
- 5 In another embodiment, the invention provides a compound having the structure:



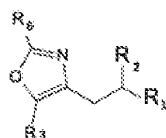
wherein R₁ is selected from COOH, COOCH₃, COOC₂H₅, COOC₅H₁₁, and COO(CH₂)₂(CH₂)₂CH₃; R₂ is selected from NH₂, NHC(O)CH₃, or NHC(O)C₂H₅;

- 10 R₄ and R₆ are each independently selected from H, Br, Cl, CF₃, CHF₂, and CCl₃.

In one embodiment, the invention provides a compound having the structure:

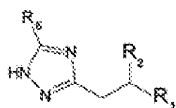


- 15 wherein R₁ is COOH; R₂ is NH₂; and R₆ is H. In yet further embodiment, the invention provides a compound having the structure:



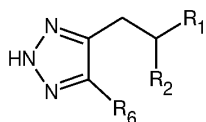
wherein R₁ is OH; R₂ is NH₂; and R₃ and R₆ are both H.

- 20 In another embodiment, the invention provides a compound having the structure:



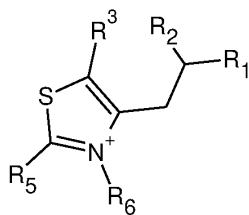
wherein R₁ is selected from COOH, COOCH₃, COOC₂H₅, COOC₅H₁₁, and COO(CH₂)₂(CH₂)₂CH₃; R₂ is selected from NH₂, NHCOCH₃, or NHCOC₂H₅; and R₆ is selected from H, Br, Cl, CF₃, CCl₃, and NH₂.

In one embodiment, the invention provides a compound having the structure:

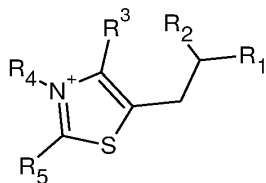


wherein R₁ is selected from COOH, COOCH₃, COOC₂H₅, COOC₅H₁₁, and COO(CH₂)₂(CH₂)₂CH₃; R₂ is selected from NH₂, NHCOCH₃, or NHCOC₂H₅; and R₆ is selected from H, Br, Cl, CF₃, CCl₃, and NH₂.

In one embodiment, the invention provides a compound having the structure:

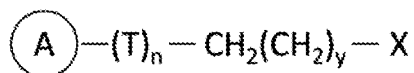


wherein R₁ is selected from COOH, COOCH₃, COOC₂H₅, COOC₅H₁₁, and COO(CH₂)₂(CH₂)₂CH₃; R₂ is selected from NH₂, NHCOCH₃, or NHCOC₂H₅; R₃ and R₅ are independently selected from H, Br, Cl, CF₃, CCl₃; and R₆ is selected from CH₃, OH and NH₂. In one embodiment, the invention provides a compound having the structure:



wherein R₁ is selected from COOH, COOCH₃, COOC₂H₅, COOC₅H₁₁, and COO(CH₂)₂(CH₂)₂CH₃; R₂ is selected from NH₂, NHCOCH₃, or NHCOC₂H₅; R₃ and R₅ are independently selected from H, Br, Cl, CF₃, CCl₃; and R₄ is selected from CH₃, OH and NH₂.

In one embodiment, provided an agricultural composition comprising a compound having the structure



or a salt thereof, wherein:

- 5 A is five, six or nine-membered ring comprising one or more heteroatoms; wherein each of the heteroatoms is independently selected from the group consisting of N, S, and O; and wherein one or more of the carbon atoms of the ring is optionally substituted with R₃, R₄, R₆ and R₇; and wherein each of R₃, R₄,
 10 R₆ or R₇ is independently selected from and an electron withdrawing group (EWG) or an electron donating group (EDG); wherein when R₃, R₄, R₆ or R₇ is EDG, at least one carbon of the ring is substituted with EWG; and wherein, when one or more heteroatoms of the ring is N or S, each independently is
 15 optionally substituted with R₃, R₄, R₆ and R₇;

T is selected from the group consisting of sulfonyl, ammonium, alkylamine; arylamine, phosphonium, nitro, cyano, dihalomethyl, acyl, formyl, haloformyls, carboxyl, alkoxy carbonyl, and aminocarbonyl;

- 20 n is 0 or 1;

y is 0 to 8;

X is

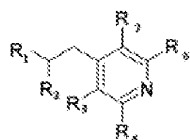


- wherein R₁ is selected from the group consisting of carboxyl
 25 group, carbamoyl group, ester with saturated or non-saturated alcohols straight, branched, cyclic chain or aromatic chain, ethylene glycol, polyethylene glycol, propylene glycol, polypropylene glycol, carboxamide substituted with straight, branched, cyclic aliphatic chain, cyclic aromatic chain,

ethylene glycol, polyethylene glycol, propylene glycol, polypropylene glycol, sulfonamide, and phosphoramidate; and wherein R₂ is selected from the group consisting of optionally substituted primary amine, secondary amine, tertiary amine, carboxamide, sulfonamide, and phosphoramidate; and at least one agriculturally acceptable carrier. In one embodiment, A is selected from the group consisting of pyrrole, pyrazole, imidazole, triazole, thiophene, dithiole, trithiole, thiazole, dithiazole, trithiazolidine, thiadiazole, dithiadiazole, thiatriazole, oxazole, furan, oxathiole, pyridine, pyridazine, pyrimidine, pyrazine, triazine, thiazine, dithiazine, thiadiazine, 2H-1,3,4,5-thiatriazine, dithiadiazine, pyrrolopyridine, pyrrolopyrimidine, pyrrolotriazine, thiopyranopyrrole, pyrrolothiazine, pyrrolodithiazine, and thienopyridine. In yet another embodiment, A is selected from the group consisting of thiophene, 2H-1,3-dithiole, 3H-1,2-dithiole, 1H-pyrrole, 2H-1,2,3-triazole, 1H-1,2,4-triazole, 1,3-thiazole, 1,2,5-thiadiazole, 1,2,4-thiadiazole, 1,3-oxazole, furan, and pyridine. In one embodiment, the EWG is selected from the group consisting of triflyl (trifluoromethanesulfonyl), trihalide, cyano, sulfonate, nitro, ammonium, quaternary amine, aldehyde, ketone, carboxylic acid, ester, amide, and halide. In one embodiment, the EDG is selected from the group consisting of phenoxide, tertiary amine, secondary amine, primary amine, ether, alkyl, phenyl and vinyl. In yet further embodiment, R₂ is primary, secondary and tertiary amine substituted with a group selected from hydrogen, an aliphatic compound with straight or branched chain, an aliphatic compound with non-aromatic ring, straight or branched-chain alcohol, alcohol with non-aromatic ring, phosphoric acid, phosphonic acid, terminal carbon of phosphonate, ethylene glycol, polyethylene glycol, propylene glycol and polypropylene glycol. In another embodiment, R₂ is selected from the group consisting of carboxamide with saturated or non-saturated

straight, branched or cyclic chain, sulfonamide, and phosphoramidate.

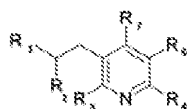
In one embodiment the composition comprises a compound having the structure:



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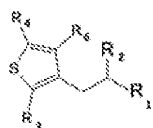
wherein R₁ is COOH, COOCH₃, COOC₂H₅, COOC₃H₇; R₂ is NH₂; R₃ and R₇ are independently selected from H, CF₃, CCl₃, Cl, and F; and R₄ and R₆ are independently selected from H, Cl, and Br. In another embodiment, the composition comprises a compound having the

10 structure:



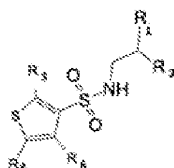
wherein R₁ is selected from COOH, COOCH₃, COOC₂H₅, and COOC₃H₇; R₂ is NH₂; R₃ and R₄ are independently selected from H, Br and Cl; and R₆ and R₇ are independently selected from H, Cl, NO₂, CF₃, and CCl₃. In yet another embodiment, the composition comprises a compound having the structure:

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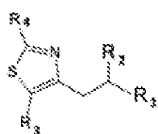


wherein R₁ is selected from COOH, COOCH₃, COOC₂H₅, COOC₄H₉, CONHCH₂COOH, and COO(CH₂)₃CH₃; R₂ is selected from NH₂, NHCOCH₃, NHCO, and NH(CH₂)₂O(CH₂)₂OH; R₃ and R₄ are independently selected from H, Cl, Br, CN, CHF₂, CF₃, CCl₃; and R₆ is H or CF₃. In one embodiment, the composition comprises a compound having the structure:

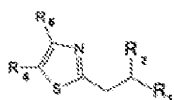
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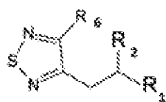
- wherein R₁ is selected from COOH, COOCH₃, COOC₂H₅, COOC₅H₁₁, and COO(CH₂)₂(CH₂)₂CH₃; R₂ is NH₂; R₃ and R₄ are independently selected from H, Br, and Cl; and R₆ is selected from H, F, Cl, Br, CF₃, CCl₃. In one embodiment, the composition comprises a compound having the structure:



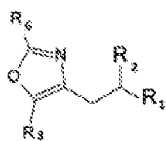
- wherein R₁ is selected from COOH, COOCH₃, COOC₂H₅, COOC₅H₁₁, and COO(CH₂)₂(CH₂)₂CH₃; R₂ is selected from NH₂, NHC(=O)CH₃, or NHC(=O)C₂H₅; R₃ and R₄ are each independently selected from H, Br, Cl, and NH₂. In another embodiment, the composition comprises a compound having the structure:



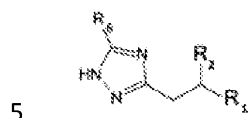
- wherein R₁ is selected from COOH, COOCH₃, COOC₂H₅, COOC₅H₁₁, and COO(CH₂)₂(CH₂)₂CH₃; R₂ is selected from NH₂, NHC(=O)CH₃, or NHC(=O)C₂H₅; R₄ and R₆ are each independently selected from H, Br, Cl, CF₃, CHF₂, and CCl₃. In one embodiment, the composition comprises a compound having the structure:



- wherein R₁ is COOH; R₂ is NH₂; and R₆ is H. In yet further embodiment, the composition comprises a compound having the structure:

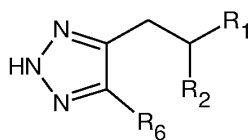


wherein R₁ is OH; R₂ is NH₂; and R₃ and R₆ are both H. In another embodiment, the composition comprises a compound having the structure:



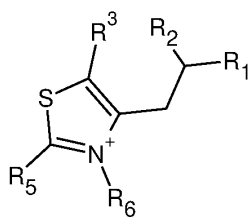
wherein R₁ is selected from COOH, COOCH₃, COOC₂H₅, COOC₅H₁₁, and COO(CH₂)₂(CH₂)₂CH₃; R₂ is selected from NH₂, NHC(=O)CH₃, or NHC(=O)C₂H₅; and R₆ is selected from H, Br, Cl, CF₃, CCl₃, and NH₂. In one embodiment, the composition comprises a compound having the structure:

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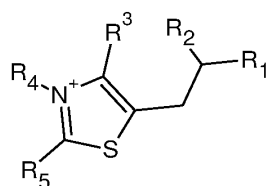
wherein R₁ is selected from COOH, COOCH₃, COOC₂H₅, COOC₅H₁₁, and COO(CH₂)₂(CH₂)₂CH₃; R₂ is selected from NH₂, NHC(=O)CH₃, or NHC(=O)C₂H₅; and R₆ is selected from H, Br, Cl, CF₃, CCl₃, and NH₂. In one embodiment, the composition comprises a compound having the structure:

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wherein R₁ is selected from COOH, COOCH₃, COOC₂H₅, COOC₅H₁₁, and COO(CH₂)₂(CH₂)₂CH₃; R₂ is selected from NH₂, NHC(=O)CH₃, or NHC(=O)C₂H₅; R₃ and R₅ are independently selected from H, Br, Cl, CF₃, CCl₃; and R₆ is selected from CH₃, OH and NH₂. In one embodiment, the composition comprises a compound having the structure:

20

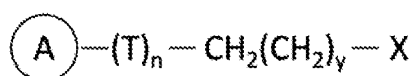


wherein R₁ is selected from COOH, COOCH₃, COOC₂H₅, COOC₅H₁₁, and COO(CH₂)₂(CH₂)₂CH₃; R₂ is selected from NH₂, NHCOCH₃, or NHCOC₂H₅; R₃ and R₅ are independently selected from H, Br, Cl, CF₃, CCl₃; and R₄ is selected from CH₃, OH and NH₂.

In one embodiment, the agricultural composition further comprises at least one crop protection agent. In another embodiment, the at least one crop protection agent is selected from the group consisting of fungicide, insecticide, herbicide, and plant growth regulator. In yet another embodiment, the crop protection agent is herbicide. In yet another embodiment, the crop protection agent is plant growth regulator. In one embodiment, the at least one crop protection agent is selected from the group consisting of atrazine, terbuthylazine, (S)-metolachlor, metolachlor, terbutryn, simazine, dimethenamid, (S)-dimethenamid, flufenacet, acetochlor, alachlor, isoxaflutole, isoxachlortole, mesotrione, sulcotrione, metosulam, flumetsulam, pendimethalin, bromoxynil, bentazone, carfentrazone-ethyl, clomazone, nicosulfuron, rimsulfuron, halosulfuron-methyl, metribuzin, flumiclorac-pentyl, prosulfuron, primisulfuron-methyl, dicamba, fluthiacet-methyl, pyridate, 2,4-D, clopyralide, diflufenzopyr, fluroxypyr, MCPA, MCPB, mecoprop (MCP), metobenzuron, thifensulfuron-methyl, aclonifen, EPTC, glyphosate, glufosinate, sulfosate, cyanazine, propaquizafop, metamitron, pyramin, phenmedipham, desmedipham, ethofumesate, triasulfuron, chloridazon, lenacil, triallate, fluazifop, sethoxydim, quizalofop, clopyralide, clethodim, oxasulfuron, acifluorfen, benazolin-ethyl, sulfentrazone, chlorimuron-ethyl, cloransulam-methyl, fomesafen, imazamox, imazaquin, imazethapyr, imazapyr, lactofen, fenoxaprop(P-

ethyl), thidiazuron, tribufos, trifluralin, dimethachlor, napropamide, quinmerac, metazachlor, carbetamide, dimefuron, propyzamide, ethametsulfuron-methyl, tebutam, fluometuron, prometryn, norflurazon, pyriithiobac-sodium, MSMA, DSMA, diuron, 5 flurochloridone, dithiopyr, thiazopyr, oxyfluorfen, ethalfluralin, clodinafop, amidosulfuron, diclofop-methyl, diflufenican, ethoxysulfuron, fentrazamide, flazasulfuron, florasulam, fluazolate, flucarbazone, flupyrsulfuron-methyl sodium, flurtamone, iodosulfuron, isoproturon, chlortoluron, 10 chlorsulfuron, metsulfuron-methyl, sulfosulfuron, tribenuron-methyl, 2,4-DB, 2,4-DP, bifenox, flamprop-M, imazamethabenz-methyl, ioxynil, tralkoxydim, fluoroglycofen-ethyl, methabenzthiazuron, isoxaben, prosulfocarb, difenzoquat-metilsulfate, pretilachlor, cinosulfuron, fenclorim, 15 bensulfuron-methyl, imazosulfuron, pyrazosulfuron-ethyl, azimsulfuron, esprocarb, mefenacet, molinate, propanil, pyrazolate, cyhalofop-butyl, bispyribac-sodium, pyriminobac-methyl, cafenstrole, oxadiargyl, oxadiazon, bromobutide, MY-100, dymron, NB 061, MK243, HW-52, AC 014, ametryn, hexazinone, 20 asulam, azafenidin, tebuthiuron, ethametsulfuron-methyl, or a combination thereof.

In one embodiment of the invention provided a method of controlling undesired plant growth comprising applying to the locus of said undesired plant growth the agricultural 25 composition comprising a compound having the structure



or a salt thereof, wherein:

A is five, six or nine-membered ring comprising one or more heteroatoms; wherein each of the heteroatoms is independently 30 selected from the group consisting of N, S, and O; and wherein one or more of the carbon atoms of the ring is optionally substituted with R₃, R₄, R₆ and R₇; and wherein each of R₃, R₄,

R₆ or R₇ is independently selected from and an electron withdrawing group (EWG) or an electron donating group (EDG); wherein when R₃, R₄, R₆ or R₇ is EDG, at least one carbon of the ring is substituted with EWG; and wherein, when one or more
 5 heteroatoms of the ring is N or S, each independently is optionally substituted with R₃, R₄, R₆ and R₇;

T is selected from the group consisting of sulfonyl, ammonium, alkylamine; arylamine, phosphonium, nitro, cyano, dihalomethyl, acyl, formyl, haloformyls, carboxyl, alkoxy carbonyl, and
 10 aminocarbonyl;

n is 0 or 1;

y is 0 to 8;

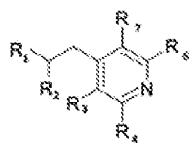
X is



15 wherein R₁ is selected from the group consisting of carboxyl group, carbamoyl group, ester with saturated or non-saturated alcohols straight, branched, cyclic chain or aromatic chain, ethylene glycol, polyethylene glycol, propylene glycol, polypropylene glycol, carboxamide substituted with straight,
 20 branched, cyclic aliphatic chain, cyclic aromatic chain, ethylene glycol, polyethylene glycol, propylene glycol, polypropylene glycol, sulfonamide, and phosphoramidate; and wherein R₂ is selected from the group consisting of optionally substituted primary amine, secondary amine, tertiary amine,
 25 carboxamide, sulfonamide, and phosphoramidate; and at least one agriculturally acceptable carrier. In one embodiment, A is selected from the group consisting of pyrrole, pyrazole, imidazole, triazole, thiophene, dithiole, trithiole, thiazole, dithiazole, trithiazolidine, thiadiazole, dithiadiazole,
 30 thiatriazole, oxazole, furan, oxathiole, pyridine, pyridazine, pyrimidine, pyrazine, triazine, thiazine, dithiazine, thiadiazine, 2H-1,3,4,5-thiatriazine, dithiadiazine,

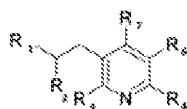
pyrrolopyridine, pyrrolopyrimidine, pyrrolotriazine, thiopyranopyrrole, pyrrolothiazine, pyrrolodithiazine, and thienopyridine. In yet another embodiment, A is selected from the group consisting of thiophene, 2H-1,3-dithiole, 3H-1,2-dithiole, 1H-pyrrole, 2H-1,2,3-triazole, 1H-1,2,4-triazole, 1,3-thiazole, 1,2,5-thiadiazole, 1,2,4-thiadiazole, 1,3-oxazole, furan, and pyridine. In one embodiment, the EWG is selected from the group consisting of triflyl (trifluoromethanesulfonyl), trihalide, cyano, sulfonate, nitro, ammonium, quaternary amine, aldehyde, ketone, carboxylic acid, ester, amide, and halide. In one embodiment, the EDG is selected from the group consisting of phenoxide, tertiary amine, secondary amine, primary amine, ether, alkyl, phenyl and vinyl. In yet further embodiment, R₂ is selected from the group consisting of primary, secondary and tertiary amine substituted with a group selected from hydrogen, an aliphatic compound with straight or branched chain, an aliphatic compound with non-aromatic ring, straight or branched-chain alcohol, alcohol with non-aromatic ring, carboxylic acid, phosphoric acid, phosphonic acid, terminal carbon of phosphonate, ethylene glycol, polyethylene glycol, propylene glycol and polypropylene glycol. In another embodiment, R₂ is selected from the group consisting of carboxamide with saturated or non-saturated straight, branched or cyclic chain, sulfonamide, and phosphoramidate.

In one embodiment the composition comprises a compound having the structure:



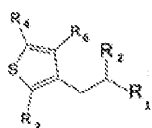
wherein R₁ is COOH, COOCH₃, COOC₂H₅, COOC₃H₇; R₂ is NH₂; R₃ and R₇ are independently selected from H, CF₃, CCl₃, Cl, and F; and R₄ and R₆ are independently selected from H, Cl, and Br.

In another embodiment, the composition comprises a compound having the structure:

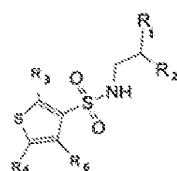


- wherein R₁ is selected from COOH, COOCH₃, COOC₂H₅, and COOC₃H₇; R₂ is NH₂; R₃ and R₄ are independently selected from H, Br and Cl; and R₆ and R₇ are independently selected from H, Cl, NO₂, CF₃, and CCl₃.

In yet another embodiment, the composition comprises a compound having the structure:

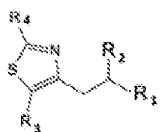


- wherein R₁ is selected from COOH, COOCH₃, COOC₂H₅, COOC₄H₉, CONHCH₂COOH, and COO(CH₂)₃CH₃; R₂ is selected from NH₂, NHCOCH₃, NHCO, and NH(CH₂)₂O(CH₂)₂OH; R₃ and R₄ are independently selected from H, Cl, Br, CN, CHF₂, CF₃, CCl₃; and R₆ is H or CF₃. In one embodiment, the composition comprises a compound having the structure:



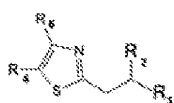
- wherein R₁ is selected from COOH, COOCH₃, COOC₂H₅, COOC₅H₁₁, and COO(CH₂)₂(CH₂)₂CH₃; R₂ is NH₂; R₃ and R₄ are independently selected from H, Br, and Cl; and R₆ is selected from H, F, Cl, Br, CF₃, CCl₃.

In one embodiment, the composition comprises a compound having the structure:



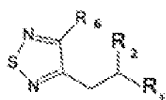
wherein R₁ is selected from COOH, COOCH₃, COOC₂H₅, COOC₅H₁₁, and
 COO(CH₂)₂(CH₂)₂CH₃; R₂ is selected from NH₂, NHCOCH₃, or NHCOC₂H₅;
 R₃ and R₄ are each independently selected from H, Br, Cl, and
 5 NH₂.

In another embodiment, the composition comprises a compound
 having the structure:



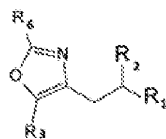
wherein R₁ is selected from COOH, COOCH₃, COOC₂H₅, COOC₅H₁₁, and
 10 COO(CH₂)₂(CH₂)₂CH₃; R₂ is selected from NH₂, NHCOCH₃, or NHCOC₂H₅;
 R₄ and R₆ are each independently selected from H, Br, Cl, CF₃,
 CHF₂, and CCl₃.

In one embodiment, the composition comprises a compound having
 the structure:



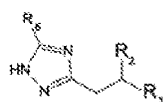
15 wherein R₁ is COOH; R₂ is NH₂; and R₆ is H.

In yet further embodiment, the composition comprises a compound
 having the structure:

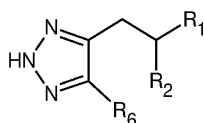


20 wherein R₁ is OH; R₂ is NH₂; and R₃ and R₆ are both H.

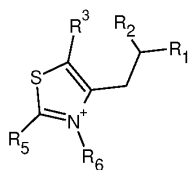
In another embodiment, the composition comprises a compound
 having the structure:



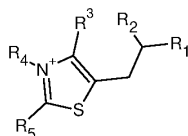
- wherein R₁ is selected from COOH, COOCH₃, COOC₂H₅, COOC₅H₁₁, and COO(CH₂)₂(CH₂)₂CH₃; R₂ is selected from NH₂, NHCOCH₃, or NHCOC₂H₅; and R₆ is selected from H, Br, Cl, CF₃, CCl₃, and NH₂. In one embodiment, the composition comprises a compound having the structure:



- wherein R₁ is selected from COOH, COOCH₃, COOC₂H₅, COOC₅H₁₁, and COO(CH₂)₂(CH₂)₂CH₃; R₂ is selected from NH₂, NHCOCH₃, or NHCOC₂H₅; and R₆ is selected from H, Br, Cl, CF₃, CCl₃, and NH₂. In one embodiment, the composition comprises a compound having the structure:



- wherein R₁ is selected from COOH, COOCH₃, COOC₂H₅, COOC₅H₁₁, and COO(CH₂)₂(CH₂)₂CH₃; R₂ is selected from NH₂, NHCOCH₃, or NHCOC₂H₅; R₃ and R₅ are independently selected from H, Br, Cl, CF₃, CCl₃; and R₆ is selected from CH₃, OH and NH₂. In one embodiment, the composition comprises a compound having the structure:



- wherein R₁ is selected from COOH, COOCH₃, COOC₂H₅, COOC₅H₁₁, and COO(CH₂)₂(CH₂)₂CH₃; R₂ is selected from NH₂, NHCOCH₃, or NHCOC₂H₅; R₃ and R₅ are independently selected from H, Br, Cl, CF₃, CCl₃; and R₄ is selected from CH₃, OH and NH₂.

In one embodiment, the method further comprises applying to the locus of the undesired plant growth at least one crop protection agent. In one embodiment, the crop protection agent is selected from the group consisting of herbicide, fungicide, insecticide and plant growth regulator. In one embodiment, the crop protection agent is herbicide. In one embodiment, the crop protection agent is amino acid synthesis inhibitor herbicide. In another embodiment, the amino acid synthesis inhibitor herbicide is selected from the group consisting of sulfonylurea herbicide, imidazolinone herbicide, sulfonamide herbicide and amino acid derivatives, or a combination thereof. In one embodiment, the amino acid synthesis inhibitor herbicide is selected from the group consisting of imazamox, imazapic, imazethapyr, imazaquin, imazapyr and imazamethabenz, or a combination thereof. In one embodiment, the amino acid synthesis inhibitor herbicide is selected from the group consisting of Chlorimuron, Primisulfuron, Thifensulfuron, Triasulfuron, Nicosulfuron, Metsulfuron, Tribenuron, Rimsulfuron and Triflusaluron or a combination thereof. In another embodiment, the amino acid synthesis inhibitor herbicide is glyphosate. In yet another embodiment the crop protection agent is a plant growth regulator. In one embodiment, the plant growth regulator is selected from the group consisting of dicamba, 2,4-D, clopyralid and fluroxypyr.

In one embodiment the invention provides a method of controlling undesired plant growth comprising applying to the locus of the undesired plant growth:

a. A first herbicide having the structure



or a salt thereof, wherein:

A is five, six or nine-membered ring comprising one or more heteroatoms; wherein each of the heteroatoms is independently selected from the group consisting of N, S, and O; and wherein one or more of the carbon atoms of the ring are optionally substituted with R₃, R₄, R₆ and R₇; and wherein each of R₃, R₄, R₆ or R₇ is independently selected from and an electron withdrawing group (EWG) or an electron donating group (EDG); wherein when R₃, R₄, R₆ or R₇ is EDG, at least one carbon of the ring is substituted with EWG; and wherein, when one or more heteroatoms of the ring is N or S, each independently is optionally substituted with R₃, R₄, R₆ and R₇;

T is selected from the group consisting of sulfonyl, ammonium, alkylamine; arylamine, phosphonium, nitro, cyano, dihalomethyl, acyl, formyl, haloformyls, carboxyl, alkoxy carbonyl, and aminocarbonyl;

n is 0 or 1;

y is 0 to 8;

X is



wherein R₁ is selected from the group consisting of carboxyl group, carbamoyl group, ester with saturated or non-saturated aliphatic straight, branched or cyclic chain, ethylene glycol, polyethylene glycol, propylene glycol, polypropylene glycol; and wherein R₂ is selected from the group consisting of optionally substituted primary amine; secondary amine; tertiary amine; and an amide derivative of carboxylic or inorganic acid; and

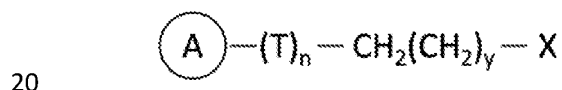
b. A second herbicide, to effectively control the undesired plant growth.

In one embodiment, the second herbicide is amino acid synthesis inhibitor herbicide. In one embodiment, the second herbicide is selected from the group consisting of sulfonylurea herbicide, imidazolinone herbicide, sulfonamide herbicide, and amino acid derivative. In another embodiment, the second herbicide is selected from the group consisting of imazamox, imazapic, imazethapyr, imazaquin, imazapyr, imazamethabenz, Chlorimuron, Primisulfuron, Thifensulfuron, Triasulfuron, Nicosulfuron, Metsulfuron, Tribenuron, Rimsulfuron, Triflusaluron, and Glyphosate. In one embodiment, the second herbicide is selected from the group consisting of atrazine, terbuthylazine, (S)-metolachlor, metolachlor, terbutryn, simazine, dimethenamid, (S)-dimethenamid, flufenacet, acetochlor, alachlor, isoxaflutole, isoxachlortole, mesotrione, sulcotrione, metosulam, flumetsulam, pendimethalin, bromoxynil, bentazone, carfentrazone-ethyl, clomazone, nicosulfuron, rimsulfuron, halosulfuron-methyl, metribuzin, flumiclorac-pentyl, prosulfuron, primisulfuron-methyl, dicamba, fluthiacet-methyl, pyridate, 2,4-D, clopyralide, diflufenzopyr, fluroxypyr, MCPA, MCPB, mecoprop (MCP), metobenzuron, thifensulfuron-methyl, acetonifene, EPTC, glyphosate, glufosinate, sulfosate, cyanazine, propaquizafop, metamitron, pyramin, phenmedipham, desmedipham, ethofumesate, triasulfuron, chloridazon, lenacil, triallate, fluzifop, sethoxydim, quizalofop, clopyralide, clethodim, oxasulfuron, acifluorfen, benazolin-ethyl, sulfentrazone, chlorimuron-ethyl, cloransulam-methyl, fomesafen, imazamox, imazaquin, imazethapyr, imazapyr, lactofen, fenoxaprop (P-ethyl), thidiazuron, tribufos, trifluralin, dimethachlor, napropamide, quinmerac, metazachlor, carbetamide, dimefuron, propyzamide, ethametsulfuron-methyl, tebutam, fluometuron, prometryn, norflurazon, pyriproxyfen-sodium, MSMA, DSMA, diuron, flurochloridone, dithiopyr, thiazopyr, oxyfluorfen, ethalfluralin, clodinafop, amidosulfuron, diclofop-methyl, diflufenican, ethoxysulfuron, fentrazamide, flazasulfuron,

florasulam, fluazolate, flucarbazone, flupyrsulfuron-methyl sodium, flurtamone, iodosulfuron, isoproturon, chlortoluron, chlorsulfuron, metsulfuron-methyl, sulfosulfuron, tribenuron-methyl, 2,4-DB, 2,4-DP, bifenox, flamprop-M, imazamethabenz-
 5 methyl, ioxynil, tralkoxydim, fluoroglycofen-ethyl, methabenzthiazuron, isoxaben, prosulfocarb, difenzoquat-metilsulfate, pretilachlor, cinosulfuron, fenclorim, bensulfuron-methyl, imazosulfuron, pyrazosulfuron-ethyl, azimsulfuron, esprocarb, mefenacet, molinate, propanil,
 10 pyrazolate, cyhalofop-butyl, bispyribac-sodium, pyriminobac-methyl, cafenstrole, oxadiargyl, oxadiazon, bromobutide, MY-100, dymron, NB 061, MK243, HW-52, AC 014, ametryn, hexazinone, asulam, azafenidin, tebuthiuron, and ethametsulfuron-methyl. In one embodiment, the method of controlling undesired plant growth
 15 further comprises applying a third herbicide or a plant growth regulator.

In one embodiment, the invention provides a composition for controlling undesired plant growth comprising a mixture of:

a. A compound having the structure



or a salt thereof, wherein:

A is five, six or nine-membered ring comprising one or more heteroatoms; wherein each of the heteroatoms is independently selected from the group consisting of N, S, and O; and wherein one or more of the carbon atoms of the
 25 ring is optionally substituted with R₃, R₄, R₆ and R₇; and wherein each of R₃, R₄, R₆ or R₇ is independently selected from an electron withdrawing group (EWG) or an electron donating group (EDG); wherein when R₃, R₄, R₆ or R₇ is EDG,
 30 at least one carbon of the ring is substituted with EWG; and, wherein, when one or more heteroatoms of the ring is N

or S, each independently is optionally substituted with R₃, R₄, R₆ and R₇;

T is selected from the group consisting of sulfonyl, ammonium, alkylamine; arylamine, phosphonium, nitro, cyano, dihalomethyl, acyl, formyl, haloformyls, carboxyl, alkoxy carbonyl, and aminocarbonyl;

n is 0 or 1;

y is 0 to 8;

X is



wherein R₁ is selected from the group consisting of carboxyl group, carbamoyl group, ester with saturated or non-saturated alcohols straight, branched, cyclic chain or aromatic chain, ethylene glycol, polyethylene glycol, propylene glycol, polypropylene glycol, carboxamide substituted with straight, branched, cyclic aliphatic chain, cyclic aromatic chain, ethylene glycol, polyethylene glycol, propylene glycol, polypropylene glycol, sulfonamide, and phosphoramidate; and wherein R₂ is selected from the group consisting of optionally substituted primary amine, secondary amine, tertiary amine, carboxamide, sulfonamide, and phosphoramidate;

- b. at least one herbicide selected from the group consisting of atrazine, terbutylazine, (S)-metolachlor, metolachlor, terbutryn, simazine, dimethenamid, (S)-dimethenamid, flufenacet, acetochlor, alachlor, isoxaflutole, isoxachlortole, mesotrione, sulcotrione, metosulam, flumetsulam, pendimethalin, bromoxynil, bentazone, carfentrazone-ethyl, clomazone, nicosulfuron, rimsulfuron, halosulfuron-methyl, metribuzin, flumiclorac-pentyl, prosulfuron, primisulfuron-methyl, dicamba, fluthiacet-

methyl, pyridate, 2,4-D, clopyralide, diflufenzopyr,
 fluroxypyr, MCPA, MCPB, mecoprop (MCP), metobenzuron,
 thifensulfuron-methyl, aclonifen, EPTC, glyphosate,
 glufosinate, sulfosate, cyanazine, propaquizafop,
 5 metamitron, pyramin, phenmedipham, desmedipham,
 ethofumesate, triasulfuron, chloridazon, lenacil,
 triallate, fluazifop, sethoxydim, quizalofop, clopyralide,
 clethodim, oxasulfuron, acifluorfen, benazolin-ethyl,
 sulfentrazone, chlorimuron-ethyl, cloransulam-methyl,
 10 fomesafen, imazamox, imazaquin, imazethapyr, imazapyr,
 lactofen, fenoxaprop (P-ethyl), thidiazuron, tribufos,
 trifluralin, dimethachlor, napropamide, quinmerac,
 metazachlor, carbetamide, dimefuron, propyzamide,
 ethametsulfuron-methyl, tebutam, fluometuron, prometryn,
 15 norflurazon, pyriithiobac-sodium, MSMA, DSMA, diuron,
 flurochloridone, dithiopyr, thiazopyr, oxyfluorfen,
 ethalfluralin, clodinafop, amidosulfuron, diclofop-methyl,
 diflufenican, ethoxysulfuron, fentrazamide, flazasulfuron,
 florasulam, fluazolate, flucarbazone, flupyrsulfuron-methyl
 20 sodium, flurtamone, iodosulfuron, isoproturon,
 chlortoluron, chlorsulfuron, metsulfuron-methyl,
 sulfosulfuron, tribenuron-methyl, 2,4-DB, 2,4-DP, bifenox,
 flamprop-M, imazamethabenz-methyl, ioxynil, tralkoxydim,
 fluoroglycofen-ethyl, methabenzthiazuron, isoxaben,
 25 prosulfocarb, difenzoquat-metilsulfate, pretilachlor,
 cinosulfuron, fenclorim, bensulfuron-methyl, imazosulfuron,
 pyrazosulfuron-ethyl, azimsulfuron, esprocarb, mefenacet,
 molinate, propanil, pyrazolate, cyhalofop-butyl,
 bispyribac-sodium, pyriminobac-methyl, cafenstrole,
 30 oxadiargyl, oxadiazon, bromobutide, MY-100, dymron, NB 061,
 MK243, HW-52, AC 014, ametryn, hexazinone, asulam,
 azafenidin, tebuthiuron, ethametsulfuron-methyl, or a
 combination thereof; and

c. at least one agriculturally acceptable carrier.

In one embodiment, A is selected from the group consisting of pyrrole, pyrazole, imidazole, triazole, thiophene, dithiole, trithiole, thiazole, dithiazole, trithiazolidine, thiadiazole, dithiadiazole, thiatriazole, oxazole, furan, oxathiole, pyridine, pyridazine, pyrimidine, pyrazine, triazine, thiazine, dithiazine, thiadiazine, 2H-1,3,4,5-thiatriazine, dithiadiazine, pyrrolopyridine, pyrrolopyrimidine, pyrrolotriazine, thiopyranopyrrole, pyrrolothiazine, pyrrolodithiazine, and thienopyridine. In yet another embodiment, A is selected from the group consisting of thiophene, 2H-1,3-dithiole, 3H-1,2-dithiole, 1H-pyrrole, 2H-1,2,3-triazole, 1H-1,2,4-triazole, 1,3-thiazole, 1,2,5-thiadiazole, 1,2,4-thiadiazole, 1,3-oxazole, furan, and pyridine. In one embodiment, the EWG is selected from the group consisting of triflyl (trifluoromethanesulfonyl), trihalide, cyano, sulfonate, nitro, ammonium, quaternary amine, aldehyde, ketone, carboxylic acid, ester, amide, and halide. In one embodiment, the EDG is selected from the group consisting of phenoxide, tertiary amine, secondary amine, primary amine, ether, alkyl, phenyl and vinyl. In yet further embodiment, R₂ is primary, secondary and tertiary amine substituted with a group selected from hydrogen, an aliphatic compound with straight or branched chain, an aliphatic compound with non-aromatic ring, straight or branched-chain alcohol, alcohol with non-aromatic ring, phosphoric acid, phosphonic acid, terminal carbon of phosphonate, ethylene glycol, polyethylene glycol, propylene glycol and polypropylene glycol. In another embodiment, R₂ is selected from the group consisting of carboxamide with saturated or non-saturated straight, branched or cyclic chain, sulfonamide, and phosphoramidate.

According to some embodiments, the invention provides a compound or a salt thereof, selected from the group consisting of: 2-amino-3-(thiophen-2-yl)propanoic acid; 2-amino-3-(thiophen-3-yl)propanoic acid; 2-amino-3-[(thiophene-3-

sulfonyl)amino]propanoic acid; 2-amino-3-[(4-fluorothiophene-3-sulfonyl)amino]propanoic acid; methyl 2-amino-3-[(thiophene-3-sulfonyl)amino]propanoate; pentyl 2-amino-3-[(thiophene-3-sulfonyl)amino]propanoate; 3-(5-cyano-3-thienyl)alanine; 2-
 5 amino-3-[4-(trifluoromethyl)thiophen-2-yl]propanoic acid; 3-amino-3-(4-bromothiophen-3-yl)propanoic acid; 2-amino-3-(2,4,5-trimethylthiophen-3-yl)propanoic acid; butyl 2-amino-3-(thiophen-3-yl)propanoate; 2-amino-3-[(2,5-dichlorothiophene-3-sulfonyl)amino]propanoic acid; 2-amino-3-[(2,5-dichloro-4-methylthiophene-3-sulfonyl)amino]propanoic acid; 2-amino-3-(2-chlorothiophen-3-yl)propanoic acid; 2-amino-3-(2,5-dichlorothiophen-3-yl)propanoic acid; 2-amino-3-(5-chlorothiophen-3-yl)propanoic acid; 2-amino-3-(2,5-dihydro-1,3-thiazol-4-yl)propanoic acid; 2-amino-3-(1,3-thiazol-5-yl)propanoic acid; 2-amino-3-[[2,5-dichloro-4-(trifluoromethyl)thiophene-3-sulfonyl]amino]propanoic acid; 2-amino-3-(2-amino-1,3-thiazol-4-yl)propanoic acid; methyl 2-amino-3-[(2,5-dichlorothiophene-3-sulfonyl)amino]propanoate; ethyl 2-amino-3-[(2,5-dichlorothiophene-3-sulfonyl)amino]propanoate; 2-propoxyethyl-2-amino-3-[(2,5-dichlorothiophene-3-sulfonyl)amino]propanoate; [2-(carboxyamino)-3-ethoxy-3-oxopropyl] (2,5-dichlorothiophene-3-sulfonyl)carbamic acid; 2-amino-3-(2,5-dichloro-1,3-thiazol-4-yl)propanoic acid; 2-amino-3-(5-chloro-1,3-thiazol-4-yl)propanoic acid; 2-amino-3-(1,2,5-thiadiazol-3-yl)propanoic acid; 2-amino-3-(1,2,4-thiadiazol-5-yl)propanoic acid; 2-amino-3-(furan-3-yl)propanoic acid; 2-amino-3-(1,3-oxazol-4-yl)propanoic acid; 2-formamido-3-(thiophen-3-yl)propanoic acid; methyl 2-amino-3-(thiophen-3-yl)propanoate; ethyl 2-amino-3-(thiophen-3-yl)propanoate; [2-amino-3-(thiophen-3-yl)propanamido]acetic acid; 2-amino-N-[2-(2-hydroxyethoxy)ethyl]-3-(thiophen-3-yl)propenamide; ethyl 2-butanamido-3-(dichloro-1,3-thiazol-4-yl)propanoate; 2-butoxyethyl 2-acetamido-3-(2,5-dichloro-1,3-thiazol-4-

yl)propanoate; 2-amino-3-(2,5-dibromothiophen-3-yl)propanoic
 acid; 2-amino-3-(5-nitrothiophen-3-yl)propanoic acid; butyl 3-
 (dichloro-1,3-thiazol-4-yl)-2-acetamidopropanoate; 2-
 ethoxyethyl 3-(dichloro-1,3-thiazol-4-yl)-2-
 5 acetamidopropanoate; 2-amino-3-[5-(trifluoromethyl)thiophen-3-
 yl]propanoic acid; (2S)-2-amino-3-(3,5-dioxo-1,2,4-
 oxadiazolidin-2-yl)propanoic acid; 2-amino-3-[(2,5-
 dibromothiophene-3-sulfonyl)amino]propanoic acid; 2-amino-3-(5-
 chloro-2-methylthiophen-3-yl)propanoic acid; 2-amino-3-(2-
 10 bromothiophen-3-yl)propanoic acid; 2-amino-3-(1,1-dioxo-1H-6-
 thiolan-3-yl)propanoic acid; 2-amino-3-(thiolan-3-yl)propanoic
 acid; [2-amino-2-(thiophen-3-yl)ethyl]phosphonic acid; 2-amino-
 3-(2,5-dimethyl-1,1-dioxo-1H-6-thiophen-3-yl)propanoic acid;
 3-(2,5-dioxo-2,5-dihydrothiophen-3-yl)-2-
 15 (phosphonoamino)propanoic acid; 2-amino-3-[4-
 (trifluoromethyl)thiophen-3-yl]propanoic acid; ethyl 2-
 acetamido-3-(2,5-dichloro-1,3-thiazol-4-yl)propanoate; methyl
 2-amino-3-(2,5-dichlorothiophen-3-yl)propanoate; ethyl 2-amino-
 3-(2,5-dichlorothiophen-3-yl)propanoate; 2-(2-
 20 methoxyethoxy)ethyl-2-amino-3-(thiophen-3-yl)propanoate; ethyl
 2-acetamido-3-(thiophen-3-yl)propanoate; ethyl 3-(2,5-
 dichlorothiophen-3-yl)-2-acetamidopropanoate; ethyl 3-(2,5-
 dichlorofuran-3-yl)-2-acetamidopropanoate; propyl 2-amino-3-
 (2,5-dichlorofuran-3-yl)propanoate; 4-(2-acetamido-3-ethoxy-3-
 25 oxopropyl)-3-methyl-1,3-thiazol-3-ium chloride; 2-(2-
 ethoxyethoxy)ethyl 3-(2,5-dichlorothiophen-3-yl)-2-
 acetamidopropanoate; pentyl 2-acetamido-3-(1,3,4-oxadiazol-2-
 yl)propanoate; ethyl-2-amino-3-[(2,5-dibromothiophene-3-
 sulfonyl)amino]propanoate; butyl 3-(5-chloro-1,2,4-thiadiazol-
 30 3-yl)-2-acetamidopropanoate; 2-amino-3-(1H-indazol-3-
 yl)propanoic acid hydrochloride[HCl]; 2-amino-3-(pyridazin-4-
 yl)propanoic acid; 2-amino-3-(pyridin-4-yl)propanoic acid; 2-
 amino-3-(pyridin-3-yl)propanoic acid dihydrochloride

3-(5-Hydroxy-3-pyridinyl)alanine; 2-amino-3-(5-methylpyridin-3-yl)propanoic acid; 2-amino-3-(4-aminopyridin-2-yl)propanoic acid; 2-amino-3-(2-aminopyridin-4-yl)propanoic acid; 2-amino-3-(6-aminopyridin-2-yl)propanoic acid; 2-amino-3-(5-aminopyridin-3-yl)propanoic acid; 2-amino-3-(5-sulfanylpiperidin-3-yl)propanoic acid; 2-amino-3-(2-sulfanylpiperidin-4-yl)propanoic acid; 2-amino-3-(pyrimidin-5-yl)propanoic acid; 2-amino-3-(4-amino-6-chloropyrimidin-2-yl)propanoic acid; 2-amino-3-(pyrimidin-2-yl)propanoic acid dihydrochloride; 2-amino-3-(4-hydroxypyrimidin-2-yl)propanoic acid; 2-amino-3-(2,4-dioxo-1,2,3,4-tetrahydropyrimidin-5-yl)propanoic acid; 2-amino-3-(pyrazin-2-yl)propanoic acid; 2-amino-3-(5-chloropyridin-3-yl)propanoic acid; 2-amino-3-(2,5-dichloropyridin-3-yl)propanoic acid; 2-amino-3-(pyrimidin-4-yl)propanoic acid; 2-amino-3-(5-fluoropyridin-3-yl)propanoic acid; 2-amino-3-(6-chloropyridin-3-yl)propanoic acid; 2-amino-3-(2,6-dichloropyridin-4-yl)propanoic acid; 2-amino-3-(3,5-dichloropyridin-4-yl)propanoic acid; 2-amino-3-(3,5-difluoropyridin-4-yl)propanoic acid; 2-amino-3-[(2-(dimethylamino)pyridin-4-yl)]propanoic acid; 2-amino-3-(2-bromopyridin-4-yl)propanoic acid; 2-amino-3-(5,6-dibromopyridin-3-yl)propanoic acid; 2-amino-3-(2,6-dibromopyridin-4-yl)propanoic acid; 2-amino-3-(2,3-dibromopyridin-4-yl)propanoic acid; 2-amino-3-[(5-(trifluoromethyl)pyridin-3-yl)]propanoic acid; 2-amino-3-(5,6-dichloropyridin-3-yl)propanoic acid; 2-amino-3-(2-oxo-1,2-dihydropyridin-4-yl)propanoic acid; 2-amino-3-[(4-(dimethylamino)pyridin-3-yl)]propanoic acid; 2-amino-3-(2-oxo-1,2-dihydropyridin-3-yl)propanoic acid; 2-amino-3-(6-oxo-1,6-dihydropyrimidin-4-yl)propanoic acid; 2-amino-3-(6-oxo-1,6-dihydropyrimidin-5-yl)propanoic acid; 2-amino-3-(6-oxo-1,6-dihydropyridin-3-yl)propanoic acid; 2-amino-3-(2,6-dioxo-1,2,3,6-tetrahydropyrimidin-4-yl)propanoic acid; 2-amino-3-(6-oxo-2-sulfanyl-1,6-dihydropyrimidin-4-yl)propanoic acid; propyl

2-amino-3-(2-bromopyridin-4-yl)propanoate; 2-amino-3-(2-bromo-3,5-difluoropyridin-4-yl)propanoic acid; propyl 2-amino-3-(2-bromo-3,5-difluoropyridin-4-yl)propanoate; 2-amino-3-[(2-bromopyridine-4-sulfonyl)amino]propanoic acid; propyl 2-amino-3-[(2-bromopyridine-4-sulfonyl)amino]propanoate; ethyl 2-amino-3-(5,6-dibromopyridin-3-yl)propanoate; ethyl 2-amino-3-(2,3-dibromopyridin-4-yl)propanoate acid; 2-amino-3-[2-chloro-5-(trifluoromethyl)pyridin-3-yl]propanoic acid; 2-amino-3-(2-amino-6-oxo-1,6-dihydropyrimidin-5-yl)propanoic acid; 2-amino-3-(6-hydroxy-5-nitropyridin-3-yl)propanoic acid; methyl 2-amino-3-(2-bromopyridin-4-yl)propanoate; 3-(2-amino-2-carboxyethyl)-1-methylpyridin-1-ium; 3-(2-amino-2-carboxyethyl)-1-hydroxypyridin-1-ium; 2-amino-3-(4-amino-6-hydroxy-2-methylpyrimidin-5-yl)propanoic acid; methyl 2-amino-3-(2,6-dibromopyridin-4-yl)propanoate; ethyl 3-(6-bromopyridin-3-yl)-2-acetamidopropanoate; methyl 3-(6-bromopyridin-3-yl)-2-acetamidopropanoate; ethyl-2-acetamido-3-(2-methoxypyrimidin-4-yl)propanoate; 2-(2-methoxyethoxy)ethyl 2-amino-3-(6-bromopyridin-3-yl)propanoate; 2-(2-ethoxyethoxy)ethyl 2-amino-3-(6-bromopyridin-3-yl)propanoate; 5-(2-amino-2-carboxyethyl)-1-methylpyrimidin-1-ium; 2-amino-3-[2-(trifluoromethyl)pyridin-4-yl]propanoic acid hydrochloride[HCl]; ethyl 3-[(2-bromopyridin-4-yl)oxy]-2-acetamidopropanoate; ethyl 2-acetamido-3-(pyridin-4-yloxy)propanoate; 2-amino-4-(1H-pyrrol-3-yl)butanoic acid; 2-amino-3-(1H-pyrrol-2-yl)propanoic acid; 2-amino-3-(1H-pyrrol-3-yl)propanoic acid; 2-amino-3-(4H-1,2,4-triazol-3-yl)propanoic acid; (2S)-2-hydroxy-3-(1H-imidazol-4-yl)propanoic acid; ethyl 2-[[(benzyloxy) carbonyl] amino]-3-(1H-1,2,4-triazol-3-yl)propanoate; 2-amino-3-(4-methyl-4H-1,2,4-triazol-3-yl)propanoic acid; 2-amino-3-(1-methyl-1H-1,2,4-triazol-5-yl)propanoic acid dihydrochloride; 2-amino-3-(1-methyl-1H-1,2,3-triazol-4-yl)propanoic acid hydrochloride; 2-amino-3-(2-methyl-2H-1,2,3,4-tetrazol-5-yl)propanoic acid hydrochloride;

2-amino-3-(dimethyl-4H-1,2,4-triazol-3-yl)propanoic acid hydrochloride; (2S)-2-amino-3-[5-(trifluoromethyl)-1H-pyrazol-4-yl]propanoic acid; and 2-(2-butoxyethoxy)ethyl 2-amino-3-(2H-1,2,3-triazol-4-yl)propanoate.

- 5 According to some embodiments, the invention provides an agricultural composition comprising the compound or a salt thereof, selected from the group consisting of: 2-amino-3-(thiophen-2-yl)propanoic acid; 2-amino-3-(thiophen-3-yl)propanoic acid; 2-amino-3-[(thiophene-3-sulfonyl)amino]propanoic acid; 2-amino-3-[(4-fluorothiophene-3-sulfonyl)amino]propanoic acid; methyl 2-amino-3-[(thiophene-3-sulfonyl)amino]propanoate; pentyl 2-amino-3-[(thiophene-3-sulfonyl)amino]propanoate; 3-(5-cyano-3-thienyl)alanine; 2-amino-3-[4-(trifluoromethyl)thiophen-2-yl]propanoic acid; 3-amino-3-(4-bromothiophen-3-yl)propanoic acid; 2-amino-3-(2,4,5-trimethylthiophen-3-yl)propanoic acid; butyl 2-amino-3-(thiophen-3-yl)propanoate; 2-amino-3-[(2,5-dichlorothiophene-3-sulfonyl)amino]propanoic acid; 2-amino-3-[(2,5-dichloro-4-methylthiophene-3-sulfonyl)amino]propanoic acid; 2-amino-3-(2-chlorothiophen-3-yl)propanoic acid; 2-amino-3-(2,5-dichlorothiophen-3-yl)propanoic acid; 2-amino-3-(5-chlorothiophen-3-yl)propanoic acid; 2-amino-3-(2,5-dihydro-1,3-thiazol-4-yl)propanoic acid; 2-amino-3-(1,3-thiazol-5-yl)propanoic acid; 2-amino-3-[[2,5-dichloro-4-(trifluoromethyl)thiophene-3-sulfonyl]amino]propanoic acid; 2-amino-3-(2-amino-1,3-thiazol-4-yl)propanoic acid; methyl 2-amino-3-[(2,5-dichlorothiophene-3-sulfonyl)amino]propanoate; ethyl 2-amino-3-[(2,5-dichlorothiophene-3-sulfonyl)amino]propanoate; 2-propoxyethyl-2-amino-3-[(2,5-dichlorothiophene-3-sulfonyl)amino]propanoate; [2-(carboxyamino)-3-ethoxy-3-oxopropyl] (2,5-dichlorothiophene-3-sulfonyl)carbamic acid; 2-amino-3-(2,5-dichloro-1,3-thiazol-4-yl)propanoic acid; 2-amino-3-(5-chloro-1,3-thiazol-4-yl)propanoic acid; 2-amino-3-(1,2,5-thiadiazol-3-yl)propanoic

acid; 2-amino-3-(1,2,4-thiadiazol-5-yl)propanoic acid; 2-amino-3-(furan-3-yl)propanoic acid; 2-amino-3-(1,3-oxazol-4-yl)propanoic acid; 2-formamido-3-(thiophen-3-yl)propanoic acid; methyl 2-amino-3-(thiophen-3-yl)propanoate; ethyl 2-amino-3-(thiophen-3-yl)propanoate; [2-amino-3-(thiophen-3-yl)propanamido]acetic acid; 2-amino-N-[2-(2-hydroxyethoxy)ethyl]-3-(thiophen-3-yl)propenamide; ethyl 2-butanamido-3-(dichloro-1,3-thiazol-4-yl)propanoate; 2-butoxyethyl 2-acetamido-3-(2,5-dichloro-1,3-thiazol-4-yl)propanoate; 2-amino-3-(2,5-dibromothiophen-3-yl)propanoic acid; 2-amino-3-(5-nitrothiophen-3-yl)propanoic acid; butyl 3-(dichloro-1,3-thiazol-4-yl)-2-acetamidopropanoate; 2-ethoxyethyl 3-(dichloro-1,3-thiazol-4-yl)-2-acetamidopropanoate; 2-amino-3-[5-(trifluoromethyl)thiophen-3-yl]propanoic acid; (2S)-2-amino-3-(3,5-dioxo-1,2,4-oxadiazolidin-2-yl)propanoic acid; 2-amino-3-[(2,5-dibromothiophene-3-sulfonyl)amino]propanoic acid; 2-amino-3-(5-chloro-2-methylthiophen-3-yl)propanoic acid; 2-amino-3-(2-bromothiophen-3-yl)propanoic acid; 2-amino-3-(1,1-dioxo-116-thiolan-3-yl)propanoic acid; 2-amino-3-(thiolan-3-yl)propanoic acid; [2-amino-2-(thiophen-3-yl)ethyl]phosphonic acid; 2-amino-3-(2,5-dimethyl-1,1-dioxo-1H-116-thiophen-3-yl)propanoic acid; 3-(2,5-dioxo-2,5-dihydrothiophen-3-yl)-2-(phosphonoamino)propanoic acid; 2-amino-3-[4-(trifluoromethyl)thiophen-3-yl]propanoic acid; ethyl 2-acetamido-3-(2,5-dichloro-1,3-thiazol-4-yl)propanoate; methyl 2-amino-3-(2,5-dichlorothiophen-3-yl)propanoate; ethyl 2-amino-3-(2,5-dichlorothiophen-3-yl)propanoate; 2-(2-methoxyethoxy)ethyl-2-amino-3-(thiophen-3-yl)propanoate; ethyl 2-acetamido-3-(thiophen-3-yl)propanoate; ethyl 3-(2,5-dichlorothiophen-3-yl)-2-acetamidopropanoate; ethyl 3-(2,5-dichlorofuran-3-yl)-2-acetamidopropanoate; propyl 2-amino-3-(2,5-dichlorofuran-3-yl)propanoate; 4-(2-acetamido-3-ethoxy-3-oxopropyl)-3-methyl-1,3-thiazol-3-ium chloride; 2-(2-

ethoxyethoxy) ethyl 3-(2,5-dichlorothiophen-3-yl)-2-acetamidopropanoate; pentyl 2-acetamido-3-(1,3,4-oxadiazol-2-yl)propanoate; ethyl-2-amino-3-[(2,5-dibromothiophene-3-sulfonyl)amino]propanoate; butyl 3-(5-chloro-1,2,4-thiadiazol-3-yl)-2-acetamidopropanoate; 2-amino-3-(1H-indazol-3-yl)propanoic acid hydrochloride[HCl]; 2-amino-3-(pyridazin-4-yl)propanoic acid; 2-amino-3-(pyridin-4-yl)propanoic acid; 2-amino-3-(pyridin-3-yl)propanoic acid dihydrochloride

3-(5-Hydroxy-3-pyridinyl)alanine; 2-amino-3-(5-methylpyridin-3-yl)propanoic acid; 2-amino-3-(4-aminopyridin-2-yl)propanoic acid; 2-amino-3-(2-aminopyridin-4-yl)propanoic acid; 2-amino-3-(6-aminopyridin-2-yl)propanoic acid; 2-amino-3-(5-aminopyridin-3-yl)propanoic acid; 2-amino-3-(5-sulfanylpiperidin-3-yl)propanoic acid; 2-amino-3-(2-sulfanylpiperidin-4-yl)propanoic acid; 2-amino-3-(pyrimidin-5-yl)propanoic acid; 2-amino-3-(4-amino-6-chloropyrimidin-2-yl)propanoic acid; 2-amino-3-(pyrimidin-2-yl)propanoic acid dihydrochloride; 2-amino-3-(4-hydroxypyrimidin-2-yl)propanoic acid; 2-amino-3-(2,4-dioxo-1,2,3,4-tetrahydropyrimidin-5-yl)propanoic acid; 2-amino-3-(pyrazin-2-yl)propanoic acid; 2-amino-3-(5-chloropyridin-3-yl)propanoic acid; 2-amino-3-(2,5-dichloropyridin-3-yl)propanoic acid; 2-amino-3-(pyrimidin-4-yl)propanoic acid; 2-amino-3-(5-fluoropyridin-3-yl)propanoic acid; 2-amino-3-(6-chloropyridin-3-yl)propanoic acid; 2-amino-3-(2,6-dichloropyridin-4-yl)propanoic acid; 2-amino-3-(3,5-dichloropyridin-4-yl)propanoic acid; 2-amino-3-(3,5-difluoropyridin-4-yl)propanoic acid; 2-amino-3-[2-(dimethylamino)pyridin-4-yl]propanoic acid; 2-amino-3-(2-bromopyridin-4-yl)propanoic acid; 2-amino-3-(5,6-dibromopyridin-3-yl)propanoic acid; 2-amino-3-(2,6-dibromopyridin-4-yl)propanoic acid; 2-amino-3-(2,3-dibromopyridin-4-yl)propanoic acid; 2-amino-3-[5-(trifluoromethyl)pyridin-3-yl]propanoic acid; 2-amino-3-(5,6-dichloropyridin-3-yl)propanoic acid; 2-amino-3-(2-oxo-1,2-

dihydropyridin-4-yl)propanoic acid; 2-amino-3-[4-(dimethylamino)pyridin-3-yl]propanoic acid; 2-amino-3-(2-oxo-1,2-dihydropyridin-3-yl)propanoic acid; 2-amino-3-(6-oxo-1,6-dihydropyrimidin-4-yl)propanoic acid; 2-amino-3-(6-oxo-1,6-dihydropyrimidin-5-yl)propanoic acid; 2-amino-3-(6-oxo-1,6-dihydropyridin-3-yl)propanoic acid; 2-amino-3-(2,6-dioxo-1,2,3,6-tetrahydropyrimidin-4-yl)propanoic acid; 2-amino-3-(6-oxo-2-sulfanyl-1,6-dihydropyrimidin-4-yl)propanoic acid; propyl 2-amino-3-(2-bromopyridin-4-yl)propanoate; 2-amino-3-(2-bromo-3,5-difluoropyridin-4-yl)propanoic acid; propyl 2-amino-3-(2-bromo-3,5-difluoropyridin-4-yl)propanoate; 2-amino-3-[(2-bromopyridine-4-sulfonyl)amino]propanoic acid; propyl 2-amino-3-[(2-bromopyridine-4-sulfonyl)amino]propanoate; ethyl 2-amino-3-(5,6-dibromopyridin-3-yl)propanoate; ethyl 2-amino-3-(2,3-dibromopyridin-4-yl)propanoate acid; 2-amino-3-[2-chloro-5-(trifluoromethyl)pyridin-3-yl]propanoic acid; 2-amino-3-(2-amino-6-oxo-1,6-dihydropyrimidin-5-yl)propanoic acid; 2-amino-3-(6-hydroxy-5-nitropyridin-3-yl)propanoic acid; methyl 2-amino-3-(2-bromopyridin-4-yl)propanoate; 3-(2-amino-2-carboxyethyl)-1-methylpyridin-1-ium; 3-(2-amino-2-carboxyethyl)-1-hydroxypyridin-1-ium; 2-amino-3-(4-amino-6-hydroxy-2-methylpyrimidin-5-yl)propanoic acid; methyl 2-amino-3-(2,6-dibromopyridin-4-yl)propanoate; ethyl 3-(6-bromopyridin-3-yl)-2-acetamidopropanoate; methyl 3-(6-bromopyridin-3-yl)-2-acetamidopropanoate; ethyl-2-acetamido-3-(2-methoxypyrimidin-4-yl)propanoate; 2-(2-methoxyethoxy)ethyl 2-amino-3-(6-bromopyridin-3-yl)propanoate; 2-(2-ethoxyethoxy)ethyl 2-amino-3-(6-bromopyridin-3-yl)propanoate; 5-(2-amino-2-carboxyethyl)-1-methylpyrimidin-1-ium; 2-amino-3-[2-(trifluoromethyl)pyridin-4-yl]propanoic acid hydrochloride[HCl]; ethyl 3-[(2-bromopyridin-4-yl)oxy]-2-acetamidopropanoate; ethyl 2-acetamido-3-(pyridin-4-yloxy)propanoate; 2-amino-4-(1H-pyrrol-3-yl)butanoic acid; 2-amino-3-(1H-pyrrol-2-yl)propanoic acid; 2-amino-3-(1H-pyrrol-3-

yl)propanoic acid; 2-amino-3-(4H-1,2,4-triazol-3-yl)propanoic acid; (2S)-2-hydroxy-3-(1H-imidazol-4-yl)propanoic acid; ethyl 2-[[(benzyloxy) carbonyl] amino]-3-(1H-1,2,4-triazol-3-yl)propanoate; 2-amino-3-(4-methyl-4H-1,2,4-triazol-3-yl)propanoic acid; 2-amino-3-(1-methyl-1H-1,2,4-triazol-5-yl)propanoic acid dihydrochloride; 2-amino-3-(1-methyl-1H-1,2,3-triazol-4-yl)propanoic acid hydrochloride; 2-amino-3-(2-methyl-2H-1,2,3,4-tetrazol-5-yl)propanoic acid hydrochloride; 2-amino-3-(dimethyl-4H-1,2,4-triazol-3-yl)propanoic acid hydrochloride; (2S)-2-amino-3-[5-(trifluoromethyl)-1H-pyrazol-4-yl]propanoic acid; and 2-(2-butoxyethoxy)ethyl 2-amino-3-(2H-1,2,3-triazol-4-yl)propanoate and at least one agriculturally acceptable carrier.

According to some embodiments, the invention provides a method of controlling undesired plant growth comprising applying to the locus of the undesired plant growth a compound or a salt thereof, selected from the group consisting of: 2-amino-3-(thiophen-2-yl)propanoic acid; 2-amino-3-(thiophen-3-yl)propanoic acid; 2-amino-3-[(thiophene-3-sulfonyl)amino]propanoic acid; 2-amino-3-[(4-fluorothiophene-3-sulfonyl)amino]propanoic acid; methyl 2-amino-3-[(thiophene-3-sulfonyl)amino]propanoate; pentyl 2-amino-3-[(thiophene-3-sulfonyl)amino]propanoate; 3-(5-cyano-3-thienyl)alanine; 2-amino-3-[4-(trifluoromethyl)thiophen-2-yl]propanoic acid; 3-amino-3-(4-bromothiophen-3-yl)propanoic acid; 2-amino-3-(2,4,5-trimethylthiophen-3-yl)propanoic acid; butyl 2-amino-3-(thiophen-3-yl)propanoate; 2-amino-3-[(2,5-dichlorothiophene-3-sulfonyl)amino]propanoic acid; 2-amino-3-[(2,5-dichloro-4-methylthiophene-3-sulfonyl)amino]propanoic acid; 2-amino-3-(2-chlorothiophen-3-yl)propanoic acid; 2-amino-3-(2,5-dichlorothiophen-3-yl)propanoic acid; 2-amino-3-(5-chlorothiophen-3-yl)propanoic acid; 2-amino-3-(2,5-dihydro-1,3-thiazol-4-yl)propanoic acid; 2-amino-3-(1,3-thiazol-5-yl)propanoic acid; 2-amino-3-[(2,5-dichloro-4-

(trifluoromethyl)thiophene-3-sulfonyl]amino}propanoic acid; 2-amino-3-(2-amino-1,3-thiazol-4-yl)propanoic acid; methyl 2-amino-3-[(2,5-dichlorothiophene-3-sulfonyl)amino]propanoate; ethyl 2-amino-3-[(2,5-dichlorothiophene-3-sulfonyl)amino]propanoate; 2-propoxyethyl-2-amino-3-[(2,5-dichlorothiophene-3-sulfonyl)amino]propanoate; [2-(carboxyamino)-3-ethoxy-3-oxopropyl] (2,5-dichlorothiophene-3-sulfonyl)carbamic acid; 2-amino-3-(2,5-dichloro-1,3-thiazol-4-yl)propanoic acid; 2-amino-3-(5-chloro-1,3-thiazol-4-yl)propanoic acid; 2-amino-3-(1,2,5-thiadiazol-3-yl)propanoic acid; 2-amino-3-(1,2,4-thiadiazol-5-yl)propanoic acid; 2-amino-3-(furan-3-yl)propanoic acid; 2-amino-3-(1,3-oxazol-4-yl)propanoic acid; 2-formamido-3-(thiophen-3-yl)propanoic acid; methyl 2-amino-3-(thiophen-3-yl)propanoate; ethyl 2-amino-3-(thiophen-3-yl)propanoate; [2-amino-3-(thiophen-3-yl)propanamido]acetic acid; 2-amino-N-[2-(2-hydroxyethoxy)ethyl]-3-(thiophen-3-yl)propenamide; ethyl 2-butanamido-3-(dichloro-1,3-thiazol-4-yl)propanoate; 2-butoxyethyl 2-acetamido-3-(2,5-dichloro-1,3-thiazol-4-yl)propanoate; 2-amino-3-(2,5-dibromothiophen-3-yl)propanoic acid; 2-amino-3-(5-nitrothiophen-3-yl)propanoic acid; butyl 3-(dichloro-1,3-thiazol-4-yl)-2-acetamidopropanoate; 2-ethoxyethyl 3-(dichloro-1,3-thiazol-4-yl)-2-acetamidopropanoate; 2-amino-3-[5-(trifluoromethyl)thiophen-3-yl]propanoic acid; (2S)-2-amino-3-(3,5-dioxo-1,2,4-oxadiazolidin-2-yl)propanoic acid; 2-amino-3-[(2,5-dibromothiophene-3-sulfonyl)amino]propanoic acid; 2-amino-3-(5-chloro-2-methylthiophen-3-yl)propanoic acid; 2-amino-3-(2-bromothiophen-3-yl)propanoic acid; 2-amino-3-(1,1-dioxo-116-thiolan-3-yl)propanoic acid; 2-amino-3-(thiolan-3-yl)propanoic acid; [2-amino-2-(thiophen-3-yl)ethyl]phosphonic acid; 2-amino-3-(2,5-dimethyl-1,1-dioxo-1H-116-thiophen-3-yl)propanoic acid; 3-(2,5-dioxo-2,5-dihydrothiophen-3-yl)-2-(phosphonoamino)propanoic acid; 2-amino-3-[4-

(trifluoromethyl)thiophen-3-yl]propanoic acid; ethyl 2-acetamido-3-(2,5-dichloro-1,3-thiazol-4-yl)propanoate; methyl 2-amino-3-(2,5-dichlorothiophen-3-yl)propanoate; ethyl 2-amino-3-(2,5-dichlorothiophen-3-yl)propanoate; 2-(2-methoxyethoxy)ethyl-2-amino-3-(thiophen-3-yl)propanoate; ethyl 2-acetamido-3-(thiophen-3-yl)propanoate; ethyl 3-(2,5-dichlorothiophen-3-yl)-2-acetamidopropanoate; ethyl 3-(2,5-dichlorofuran-3-yl)-2-acetamidopropanoate; propyl 2-amino-3-(2,5-dichlorofuran-3-yl)propanoate; 4-(2-acetamido-3-ethoxy-3-oxopropyl)-3-methyl-1,3-thiazol-3-ium chloride; 2-(2-ethoxyethoxy)ethyl 3-(2,5-dichlorothiophen-3-yl)-2-acetamidopropanoate; pentyl 2-acetamido-3-(1,3,4-oxadiazol-2-yl)propanoate; ethyl-2-amino-3-[(2,5-dibromothiophene-3-sulfonyl)amino]propanoate; butyl 3-(5-chloro-1,2,4-thiadiazol-3-yl)-2-acetamidopropanoate; 2-amino-3-(1H-indazol-3-yl)propanoic acid hydrochloride[HCl]; 2-amino-3-(pyridazin-4-yl)propanoic acid; 2-amino-3-(pyridin-4-yl)propanoic acid; 2-amino-3-(pyridin-3-yl)propanoic acid dihydrochloride

3-(5-Hydroxy-3-pyridinyl)alanine; 2-amino-3-(5-methylpyridin-3-yl)propanoic acid; 2-amino-3-(4-aminopyridin-2-yl)propanoic acid; 2-amino-3-(2-aminopyridin-4-yl)propanoic acid; 2-amino-3-(6-aminopyridin-2-yl)propanoic acid; 2-amino-3-(5-aminopyridin-3-yl)propanoic acid; 2-amino-3-(5-sulfanylpiperidin-3-yl)propanoic acid; 2-amino-3-(2-sulfanylpiperidin-4-yl)propanoic acid; 2-amino-3-(pyrimidin-5-yl)propanoic acid; 2-amino-3-(4-amino-6-chloropyrimidin-2-yl)propanoic acid; 2-amino-3-(pyrimidin-2-yl)propanoic acid dihydrochloride; 2-amino-3-(4-hydroxypyrimidin-2-yl)propanoic acid; 2-amino-3-(2,4-dioxo-1,2,3,4-tetrahydropyrimidin-5-yl)propanoic acid; 2-amino-3-(pyrazin-2-yl)propanoic acid; 2-amino-3-(5-chloropyridin-3-yl)propanoic acid; 2-amino-3-(2,5-dichloropyridin-3-yl)propanoic acid; 2-amino-3-(pyrimidin-4-yl)propanoic acid; 2-amino-3-(5-fluoropyridin-3-yl)propanoic acid; 2-amino-3-(6-chloropyridin-3-yl)propanoic acid; 2-amino-3-(2,6-

- dichloropyridin-4-yl)propanoic acid; 2-amino-3-(3,5-dichloropyridin-4-yl)propanoic acid; 2-amino-3-(3,5-difluoropyridin-4-yl)propanoic acid; 2-amino-3-[2-(dimethylamino)pyridin-4-yl]propanoic acid; 2-amino-3-(2-bromopyridin-4-yl)propanoic acid; 2-amino-3-(5,6-dibromopyridin-3-yl)propanoic acid; 2-amino-3-(2,6-dibromopyridin-4-yl)propanoic acid; 2-amino-3-(2,3-dibromopyridin-4-yl)propanoic acid; 2-amino-3-[5-(trifluoromethyl)pyridin-3-yl]propanoic acid; 2-amino-3-(5,6-dichloropyridin-3-yl)propanoic acid; 2-amino-3-(2-oxo-1,2-dihydropyridin-4-yl)propanoic acid; 2-amino-3-[4-(dimethylamino)pyridin-3-yl]propanoic acid; 2-amino-3-(2-oxo-1,2-dihydropyridin-3-yl)propanoic acid; 2-amino-3-(6-oxo-1,6-dihydropyrimidin-4-yl)propanoic acid; 2-amino-3-(6-oxo-1,6-dihydropyrimidin-5-yl)propanoic acid; 2-amino-3-(6-oxo-1,6-dihydropyridin-3-yl)propanoic acid; 2-amino-3-(2,6-dioxo-1,2,3,6-tetrahydropyrimidin-4-yl)propanoic acid; 2-amino-3-(6-oxo-2-sulfanyl-1,6-dihydropyrimidin-4-yl)propanoic acid; propyl 2-amino-3-(2-bromopyridin-4-yl)propanoate; 2-amino-3-(2-bromo-3,5-difluoropyridin-4-yl)propanoic acid; propyl 2-amino-3-(2-bromo-3,5-difluoropyridin-4-yl)propanoate; 2-amino-3-[(2-bromopyridine-4-sulfonyl)amino]propanoic acid; propyl 2-amino-3-[(2-bromopyridine-4-sulfonyl)amino]propanoate; ethyl 2-amino-3-(5,6-dibromopyridin-3-yl)propanoate; ethyl 2-amino-3-(2,3-dibromopyridin-4-yl)propanoate acid; 2-amino-3-[2-chloro-5-(trifluoromethyl)pyridin-3-yl]propanoic acid; 2-amino-3-(2-amino-6-oxo-1,6-dihydropyrimidin-5-yl)propanoic acid; 2-amino-3-(6-hydroxy-5-nitropyridin-3-yl)propanoic acid; methyl 2-amino-3-(2-bromopyridin-4-yl)propanoate; 3-(2-amino-2-carboxyethyl)-1-methylpyridin-1-ium; 3-(2-amino-2-carboxyethyl)-1-hydroxypyridin-1-ium; 2-amino-3-(4-amino-6-hydroxy-2-methylpyrimidin-5-yl)propanoic acid; methyl 2-amino-3-(2,6-dibromopyridin-4-yl)propanoate; ethyl 3-(6-bromopyridin-3-yl)-2-acetamidopropanoate; methyl 3-(6-bromopyridin-3-yl)-2-

acetamidopropanoate; ethyl-2-acetamido-3-(2-methoxypyrimidin-4-yl)propanoate; 2-(2-methoxyethoxy)ethyl 2-amino-3-(6-bromopyridin-3-yl)propanoate; 2-(2-ethoxyethoxy)ethyl 2-amino-3-(6-bromopyridin-3-yl)propanoate; 5-(2-amino-2-carboxyethyl)-1-methylpyrimidin-1-ium; 2-amino-3-[2-(trifluoromethyl)pyridin-4-yl]propanoic acid hydrochloride[HCl]; ethyl 3-[(2-bromopyridin-4-yl)oxy]-2-acetamidopropanoate; ethyl 2-acetamido-3-(pyridin-4-yloxy)propanoate; 2-amino-4-(1H-pyrrol-3-yl)butanoic acid; 2-amino-3-(1H-pyrrol-2-yl)propanoic acid; 2-amino-3-(1H-pyrrol-3-yl)propanoic acid; 2-amino-3-(4H-1,2,4-triazol-3-yl)propanoic acid; (2S)-2-hydroxy-3-(1H-imidazol-4-yl)propanoic acid; ethyl 2-[[(benzyloxy) carbonyl] amino]-3-(1H-1,2,4-triazol-3-yl)propanoate; 2-amino-3-(4-methyl-4H-1,2,4-triazol-3-yl)propanoic acid; 2-amino-3-(1-methyl-1H-1,2,4-triazol-5-yl)propanoic acid dihydrochloride; 2-amino-3-(1-methyl-1H-1,2,3-triazol-4-yl)propanoic acid hydrochloride; 2-amino-3-(2-methyl-2H-1,2,3,4-tetrazol-5-yl)propanoic acid hydrochloride; 2-amino-3-(dimethyl-4H-1,2,4-triazol-3-yl)propanoic acid hydrochloride; (2S)-2-amino-3-[5-(trifluoromethyl)-1H-pyrazol-4-yl]propanoic acid; and 2-(2-butoxyethoxy)ethyl 2-amino-3-(2H-1,2,3-triazol-4-yl)propanoate.

According to some embodiments, the invention provides a composition for controlling undesired plant growth comprising a mixture of: a) a compound selected from the group consisting of: 2-amino-3-(thiophen-2-yl)propanoic acid; 2-amino-3-(thiophen-3-yl)propanoic acid; 2-amino-3-[(thiophene-3-sulfonyl) amino]propanoic acid; 2-amino-3-[(4-fluorothiophene-3-sulfonyl) amino]propanoic acid; methyl 2-amino-3-[(thiophene-3-sulfonyl) amino]propanoate; pentyl 2-amino-3-[(thiophene-3-sulfonyl) amino]propanoate; 3-(5-cyano-3-thienyl)alanine; 2-amino-3-[4-(trifluoromethyl)thiophen-2-yl]propanoic acid; 3-amino-3-(4-bromothiophen-3-yl)propanoic acid; 2-amino-3-(2,4,5-trimethylthiophen-3-yl)propanoic acid; butyl 2-amino-3-

(thiophen-3-yl)propanoate; 2-amino-3-[(2,5-dichlorothiophene-3-sulfonyl)amino]propanoic acid; 2-amino-3-[(2,5-dichloro-4-methylthiophene-3-sulfonyl)amino]propanoic acid; 2-amino-3-(2-chlorothiophen-3-yl)propanoic acid; 2-amino-3-(2,5-dichlorothiophen-3-yl)propanoic acid; 2-amino-3-(5-chlorothiophen-3-yl)propanoic acid; 2-amino-3-(2,5-dihydro-1,3-thiazol-4-yl)propanoic acid; 2-amino-3-(1,3-thiazol-5-yl)propanoic acid; 2-amino-3-[[2,5-dichloro-4-(trifluoromethyl)thiophene-3-sulfonyl]amino]propanoic acid; 2-amino-3-(2-amino-1,3-thiazol-4-yl)propanoic acid; methyl 2-amino-3-[(2,5-dichlorothiophene-3-sulfonyl)amino]propanoate; ethyl 2-amino-3-[(2,5-dichlorothiophene-3-sulfonyl)amino]propanoate; 2-propoxyethyl-2-amino-3-[(2,5-dichlorothiophene-3-sulfonyl)amino]propanoate; [2-(carboxyamino)-3-ethoxy-3-oxopropyl] (2,5-dichlorothiophene-3-sulfonyl)carbamic acid; 2-amino-3-(2,5-dichloro-1,3-thiazol-4-yl)propanoic acid; 2-amino-3-(5-chloro-1,3-thiazol-4-yl)propanoic acid; 2-amino-3-(1,2,5-thiadiazol-3-yl)propanoic acid; 2-amino-3-(1,2,4-thiadiazol-5-yl)propanoic acid; 2-amino-3-(furan-3-yl)propanoic acid; 2-amino-3-(1,3-oxazol-4-yl)propanoic acid; 2-formamido-3-(thiophen-3-yl)propanoic acid; methyl 2-amino-3-(thiophen-3-yl)propanoate; ethyl 2-amino-3-(thiophen-3-yl)propanoate; [2-amino-3-(thiophen-3-yl)propanamido]acetic acid; 2-amino-N-[2-(2-hydroxyethoxy)ethyl]-3-(thiophen-3-yl)propenamide; ethyl 2-butanamido-3-(dichloro-1,3-thiazol-4-yl)propanoate; 2-butoxyethyl 2-acetamido-3-(2,5-dichloro-1,3-thiazol-4-yl)propanoate; 2-amino-3-(2,5-dibromothiophen-3-yl)propanoic acid; 2-amino-3-(5-nitrothiophen-3-yl)propanoic acid; butyl 3-(dichloro-1,3-thiazol-4-yl)-2-acetamidopropanoate; 2-ethoxyethyl 3-(dichloro-1,3-thiazol-4-yl)-2-acetamidopropanoate; 2-amino-3-[5-(trifluoromethyl)thiophen-3-yl]propanoic acid; (2S)-2-amino-3-(3,5-dioxo-1,2,4-oxadiazolidin-2-yl)propanoic acid; 2-amino-3-[(2,5-

dibromothiophene-3-sulfonyl)amino]propanoic acid; 2-amino-3-(5-chloro-2-methylthiophen-3-yl)propanoic acid; 2-amino-3-(2-bromothiophen-3-yl)propanoic acid; 2-amino-3-(1,1-dioxo-116-thiolan-3-yl)propanoic acid; 2-amino-3-(thiolan-3-yl)propanoic acid; [2-amino-2-(thiophen-3-yl)ethyl]phosphonic acid; 2-amino-3-(2,5-dimethyl-1,1-dioxo-1H-116-thiophen-3-yl)propanoic acid; 3-(2,5-dioxo-2,5-dihydrothiophen-3-yl)-2-(phosphonoamino)propanoic acid; 2-amino-3-[4-(trifluoromethyl)thiophen-3-yl]propanoic acid; ethyl 2-acetamido-3-(2,5-dichloro-1,3-thiazol-4-yl)propanoate; methyl 2-amino-3-(2,5-dichlorothiophen-3-yl)propanoate; ethyl 2-amino-3-(2,5-dichlorothiophen-3-yl)propanoate; 2-(2-methoxyethoxy)ethyl-2-amino-3-(thiophen-3-yl)propanoate; ethyl 2-acetamido-3-(thiophen-3-yl)propanoate; ethyl 3-(2,5-dichlorothiophen-3-yl)-2-acetamidopropanoate; ethyl 3-(2,5-dichlorofuran-3-yl)-2-acetamidopropanoate; propyl 2-amino-3-(2,5-dichlorofuran-3-yl)propanoate; 4-(2-acetamido-3-ethoxy-3-oxopropyl)-3-methyl-1,3-thiazol-3-ium chloride; 2-(2-ethoxyethoxy)ethyl 3-(2,5-dichlorothiophen-3-yl)-2-acetamidopropanoate; pentyl 2-acetamido-3-(1,3,4-oxadiazol-2-yl)propanoate; ethyl-2-amino-3-[(2,5-dibromothiophene-3-sulfonyl)amino]propanoate; butyl 3-(5-chloro-1,2,4-thiadiazol-3-yl)-2-acetamidopropanoate; 2-amino-3-(1H-indazol-3-yl)propanoic acid hydrochloride[HCl]; 2-amino-3-(pyridazin-4-yl)propanoic acid; 2-amino-3-(pyridin-4-yl)propanoic acid; 2-amino-3-(pyridin-3-yl)propanoic acid dihydrochloride
 3-(5-Hydroxy-3-pyridinyl)alanine; 2-amino-3-(5-methylpyridin-3-yl)propanoic acid; 2-amino-3-(4-aminopyridin-2-yl)propanoic acid; 2-amino-3-(2-aminopyridin-4-yl)propanoic acid; 2-amino-3-(6-aminopyridin-2-yl)propanoic acid; 2-amino-3-(5-aminopyridin-3-yl)propanoic acid; 2-amino-3-(5-sulfanylpiperidin-3-yl)propanoic acid; 2-amino-3-(2-sulfanylpiperidin-4-yl)propanoic acid; 2-amino-3-(pyrimidin-5-yl)propanoic acid; 2-amino-3-(4-amino-6-chloropyrimidin-2-yl)propanoic acid; 2-amino-3-

(pyrimidin-2-yl)propanoic acid dihydrochloride; 2-amino-3-(4-hydroxypyrimidin-2-yl)propanoic acid; 2-amino-3-(2,4-dioxo-1,2,3,4-tetrahydropyrimidin-5-yl)propanoic acid; 2-amino-3-(pyrazin-2-yl)propanoic acid; 2-amino-3-(5-chloropyridin-3-yl)propanoic acid; 2-amino-3-(2,5-dichloropyridin-3-yl)propanoic acid; 2-amino-3-(pyrimidin-4-yl)propanoic acid; 2-amino-3-(5-fluoropyridin-3-yl)propanoic acid; 2-amino-3-(6-chloropyridin-3-yl)propanoic acid; 2-amino-3-(2,6-dichloropyridin-4-yl)propanoic acid; 2-amino-3-(3,5-dichloropyridin-4-yl)propanoic acid; 2-amino-3-(3,5-difluoropyridin-4-yl)propanoic acid; 2-amino-3-[2-(dimethylamino)pyridin-4-yl]propanoic acid; 2-amino-3-(2-bromopyridin-4-yl)propanoic acid; 2-amino-3-(5,6-dibromopyridin-3-yl)propanoic acid; 2-amino-3-(2,6-dibromopyridin-4-yl)propanoic acid; 2-amino-3-(2,3-dibromopyridin-4-yl)propanoic acid; 2-amino-3-[5-(trifluoromethyl)pyridin-3-yl]propanoic acid; 2-amino-3-(5,6-dichloropyridin-3-yl)propanoic acid; 2-amino-3-(2-oxo-1,2-dihydropyridin-4-yl)propanoic acid; 2-amino-3-[4-(dimethylamino)pyridin-3-yl]propanoic acid; 2-amino-3-(2-oxo-1,2-dihydropyridin-3-yl)propanoic acid; 2-amino-3-(6-oxo-1,6-dihydropyrimidin-4-yl)propanoic acid; 2-amino-3-(6-oxo-1,6-dihydropyrimidin-5-yl)propanoic acid; 2-amino-3-(6-oxo-1,6-dihydropyridin-3-yl)propanoic acid; 2-amino-3-(2,6-dioxo-1,2,3,6-tetrahydropyrimidin-4-yl)propanoic acid; 2-amino-3-(6-oxo-2-sulfanyl-1,6-dihydropyrimidin-4-yl)propanoic acid; propyl 2-amino-3-(2-bromopyridin-4-yl)propanoate; 2-amino-3-(2-bromo-3,5-difluoropyridin-4-yl)propanoic acid; propyl 2-amino-3-(2-bromo-3,5-difluoropyridin-4-yl)propanoate; 2-amino-3-[(2-bromopyridine-4-sulfonyl)amino]propanoic acid; propyl 2-amino-3-[(2-bromopyridine-4-sulfonyl)amino]propanoate; ethyl 2-amino-3-(5,6-dibromopyridin-3-yl)propanoate; ethyl 2-amino-3-(2,3-dibromopyridin-4-yl)propanoate acid; 2-amino-3-[2-chloro-5-(trifluoromethyl)pyridin-3-yl]propanoic acid; 2-amino-3-(2-

amino-6-oxo-1,6-dihydropyrimidin-5-yl)propanoic acid; 2-amino-3-(6-hydroxy-5-nitropyridin-3-yl)propanoic acid; methyl 2-amino-3-(2-bromopyridin-4-yl)propanoate; 3-(2-amino-2-carboxyethyl)-1-methylpyridin-1-ium; 3-(2-amino-2-carboxyethyl)-1-hydroxypyridin-1-ium; 2-amino-3-(4-amino-6-hydroxy-2-methylpyrimidin-5-yl)propanoic acid; methyl 2-amino-3-(2,6-dibromopyridin-4-yl)propanoate; ethyl 3-(6-bromopyridin-3-yl)-2-acetamidopropanoate; methyl 3-(6-bromopyridin-3-yl)-2-acetamidopropanoate; ethyl-2-acetamido-3-(2-methoxypyrimidin-4-yl)propanoate; 2-(2-methoxyethoxy)ethyl 2-amino-3-(6-bromopyridin-3-yl)propanoate; 2-(2-ethoxyethoxy)ethyl 2-amino-3-(6-bromopyridin-3-yl)propanoate; 5-(2-amino-2-carboxyethyl)-1-methylpyrimidin-1-ium; 2-amino-3-[2-(trifluoromethyl)pyridin-4-yl]propanoic acid hydrochloride[HCl]; ethyl 3-[(2-bromopyridin-4-yl)oxy]-2-acetamidopropanoate; ethyl 2-acetamido-3-(pyridin-4-yloxy)propanoate; 2-amino-4-(1H-pyrrol-3-yl)butanoic acid; 2-amino-3-(1H-pyrrol-2-yl)propanoic acid; 2-amino-3-(1H-pyrrol-3-yl)propanoic acid; 2-amino-3-(4H-1,2,4-triazol-3-yl)propanoic acid; (2S)-2-hydroxy-3-(1H-imidazol-4-yl)propanoic acid; ethyl 2-{[(benzyloxy)carbonyl]amino}-3-(1H-1,2,4-triazol-3-yl)propanoate; 2-amino-3-(4-methyl-4H-1,2,4-triazol-3-yl)propanoic acid; 2-amino-3-(1-methyl-1H-1,2,4-triazol-5-yl)propanoic acid dihydrochloride; 2-amino-3-(1-methyl-1H-1,2,3-triazol-4-yl)propanoic acid hydrochloride; 2-amino-3-(2-methyl-2H-1,2,3,4-tetrazol-5-yl)propanoic acid hydrochloride; 2-amino-3-(dimethyl-4H-1,2,4-triazol-3-yl)propanoic acid hydrochloride; (2S)-2-amino-3-[5-(trifluoromethyl)-1H-pyrazol-4-yl]propanoic acid; and 2-(2-butoxyethoxy)ethyl 2-amino-3-(2H-1,2,3-triazol-4-yl)propanoate; b) a second herbicide; and, c) at least one agriculturally acceptable carrier.

According to some embodiments, the invention provides a mixture comprising: a) a compound selected from the group consisting of 2-amino-3-(thiophen-2-yl)propanoic acid; 2-amino-3-(thiophen-3-

yl)propanoic acid; 2-amino-3-[(thiophene-3-sulfonyl)amino]propanoic acid; 2-amino-3-[(4-fluorothiophene-3-sulfonyl)amino]propanoic acid; methyl 2-amino-3-[(thiophene-3-sulfonyl)amino]propanoate; pentyl 2-amino-3-[(thiophene-3-sulfonyl)amino]propanoate; 3-(5-cyano-3-thienyl)alanine; 2-amino-3-[4-(trifluoromethyl)thiophen-2-yl]propanoic acid; 3-amino-3-(4-bromothiophen-3-yl)propanoic acid; 2-amino-3-(2,4,5-trimethylthiophen-3-yl)propanoic acid; butyl 2-amino-3-(thiophen-3-yl)propanoate; 2-amino-3-[(2,5-dichlorothiophene-3-sulfonyl)amino]propanoic acid; 2-amino-3-[(2,5-dichloro-4-methylthiophene-3-sulfonyl)amino]propanoic acid; 2-amino-3-(2-chlorothiophen-3-yl)propanoic acid; 2-amino-3-(2,5-dichlorothiophen-3-yl)propanoic acid; 2-amino-3-(5-chlorothiophen-3-yl)propanoic acid; 2-amino-3-(2,5-dihydro-1,3-thiazol-4-yl)propanoic acid; 2-amino-3-(1,3-thiazol-5-yl)propanoic acid; 2-amino-3-[[2,5-dichloro-4-(trifluoromethyl)thiophene-3-sulfonyl]amino]propanoic acid; 2-amino-3-(2-amino-1,3-thiazol-4-yl)propanoic acid; methyl 2-amino-3-[(2,5-dichlorothiophene-3-sulfonyl)amino]propanoate; ethyl 2-amino-3-[(2,5-dichlorothiophene-3-sulfonyl)amino]propanoate; 2-propoxyethyl-2-amino-3-[(2,5-dichlorothiophene-3-sulfonyl)amino]propanoate; [2-(carboxyamino)-3-ethoxy-3-oxopropyl] (2,5-dichlorothiophene-3-sulfonyl)carbamic acid; 2-amino-3-(2,5-dichloro-1,3-thiazol-4-yl)propanoic acid; 2-amino-3-(5-chloro-1,3-thiazol-4-yl)propanoic acid; 2-amino-3-(1,2,5-thiadiazol-3-yl)propanoic acid; 2-amino-3-(1,2,4-thiadiazol-5-yl)propanoic acid; 2-amino-3-(furan-3-yl)propanoic acid; 2-amino-3-(1,3-oxazol-4-yl)propanoic acid; 2-formamido-3-(thiophen-3-yl)propanoic acid; methyl 2-amino-3-(thiophen-3-yl)propanoate; ethyl 2-amino-3-(thiophen-3-yl)propanoate; [2-amino-3-(thiophen-3-yl)propanamido]acetic acid; 2-amino-N-[2-(2-hydroxyethoxy)ethyl]-3-(thiophen-3-yl)propenamide; ethyl 2-butanamido-3-(dichloro-1,3-thiazol-4-yl)propanoate; 2-

butoxyethyl 2-acetamido-3-(2,5-dichloro-1,3-thiazol-4-yl)propanoate; 2-amino-3-(2,5-dibromothiophen-3-yl)propanoic acid; 2-amino-3-(5-nitrothiophen-3-yl)propanoic acid; butyl 3-(dichloro-1,3-thiazol-4-yl)-2-acetamidopropanoate; 2-ethoxyethyl 3-(dichloro-1,3-thiazol-4-yl)-2-acetamidopropanoate; 2-amino-3-[5-(trifluoromethyl)thiophen-3-yl]propanoic acid; (2S)-2-amino-3-(3,5-dioxo-1,2,4-oxadiazolidin-2-yl)propanoic acid; 2-amino-3-[(2,5-dibromothiophene-3-sulfonyl)amino]propanoic acid; 2-amino-3-(5-chloro-2-methylthiophen-3-yl)propanoic acid; 2-amino-3-(2-bromothiophen-3-yl)propanoic acid; 2-amino-3-(1,1-dioxo-1H-1,2,4-thiolan-3-yl)propanoic acid; 2-amino-3-(thiolan-3-yl)propanoic acid; [2-amino-2-(thiophen-3-yl)ethyl]phosphonic acid; 2-amino-3-(2,5-dimethyl-1,1-dioxo-1H-1,2,4-thiophen-3-yl)propanoic acid; 3-(2,5-dioxo-2,5-dihydrothiophen-3-yl)-2-(phosphonoamino)propanoic acid; 2-amino-3-[4-(trifluoromethyl)thiophen-3-yl]propanoic acid; ethyl 2-acetamido-3-(2,5-dichloro-1,3-thiazol-4-yl)propanoate; methyl 2-amino-3-(2,5-dichlorothiophen-3-yl)propanoate; ethyl 2-amino-3-(2,5-dichlorothiophen-3-yl)propanoate; 2-(2-methoxyethoxy)ethyl 2-amino-3-(thiophen-3-yl)propanoate; ethyl 2-acetamido-3-(thiophen-3-yl)propanoate; ethyl 3-(2,5-dichlorothiophen-3-yl)-2-acetamidopropanoate; ethyl 3-(2,5-dichlorofuran-3-yl)-2-acetamidopropanoate; propyl 2-amino-3-(2,5-dichlorofuran-3-yl)propanoate; 4-(2-acetamido-3-ethoxy-3-oxopropyl)-3-methyl-1,3-thiazol-3-ium chloride; 2-(2-ethoxyethoxy)ethyl 3-(2,5-dichlorothiophen-3-yl)-2-acetamidopropanoate; pentyl 2-acetamido-3-(1,3,4-oxadiazol-2-yl)propanoate; ethyl 2-amino-3-[(2,5-dibromothiophene-3-sulfonyl)amino]propanoate; butyl 3-(5-chloro-1,2,4-thiadiazol-3-yl)-2-acetamidopropanoate; 2-amino-3-(1H-indazol-3-yl)propanoic acid hydrochloride[HCl]; 2-amino-3-(pyridazin-4-yl)propanoic acid; 2-amino-3-(pyridin-4-yl)propanoic acid; 2-amino-3-(pyridin-3-yl)propanoic acid dihydrochloride

3-(5-Hydroxy-3-pyridinyl)alanine; 2-amino-3-(5-methylpyridin-3-yl)propanoic acid; 2-amino-3-(4-aminopyridin-2-yl)propanoic acid; 2-amino-3-(2-aminopyridin-4-yl)propanoic acid; 2-amino-3-(6-aminopyridin-2-yl)propanoic acid; 2-amino-3-(5-aminopyridin-3-yl)propanoic acid; 2-amino-3-(5-sulfanylpiperidin-3-yl)propanoic acid; 2-amino-3-(2-sulfanylpiperidin-4-yl)propanoic acid; 2-amino-3-(pyrimidin-5-yl)propanoic acid; 2-amino-3-(4-amino-6-chloropyrimidin-2-yl)propanoic acid; 2-amino-3-(pyrimidin-2-yl)propanoic acid dihydrochloride; 2-amino-3-(4-hydroxypyrimidin-2-yl)propanoic acid; 2-amino-3-(2,4-dioxo-1,2,3,4-tetrahydropyrimidin-5-yl)propanoic acid; 2-amino-3-(pyrazin-2-yl)propanoic acid; 2-amino-3-(5-chloropyridin-3-yl)propanoic acid; 2-amino-3-(2,5-dichloropyridin-3-yl)propanoic acid; 2-amino-3-(pyrimidin-4-yl)propanoic acid; 2-amino-3-(5-fluoropyridin-3-yl)propanoic acid; 2-amino-3-(6-chloropyridin-3-yl)propanoic acid; 2-amino-3-(2,6-dichloropyridin-4-yl)propanoic acid; 2-amino-3-(3,5-dichloropyridin-4-yl)propanoic acid; 2-amino-3-(3,5-difluoropyridin-4-yl)propanoic acid; 2-amino-3-[(2-(dimethylamino)pyridin-4-yl)]propanoic acid; 2-amino-3-(2-bromopyridin-4-yl)propanoic acid; 2-amino-3-(5,6-dibromopyridin-3-yl)propanoic acid; 2-amino-3-(2,6-dibromopyridin-4-yl)propanoic acid; 2-amino-3-(2,3-dibromopyridin-4-yl)propanoic acid; 2-amino-3-[(5-(trifluoromethyl)pyridin-3-yl)]propanoic acid; 2-amino-3-(5,6-dichloropyridin-3-yl)propanoic acid; 2-amino-3-(2-oxo-1,2-dihydropyridin-4-yl)propanoic acid; 2-amino-3-[(4-(dimethylamino)pyridin-3-yl)]propanoic acid; 2-amino-3-(2-oxo-1,2-dihydropyridin-3-yl)propanoic acid; 2-amino-3-(6-oxo-1,6-dihydropyrimidin-4-yl)propanoic acid; 2-amino-3-(6-oxo-1,6-dihydropyrimidin-5-yl)propanoic acid; 2-amino-3-(6-oxo-1,6-dihydropyridin-3-yl)propanoic acid; 2-amino-3-(2,6-dioxo-1,2,3,6-tetrahydropyrimidin-4-yl)propanoic acid; 2-amino-3-(6-oxo-2-sulfanyl-1,6-dihydropyrimidin-4-yl)propanoic acid; propyl

2-amino-3-(2-bromopyridin-4-yl)propanoate; 2-amino-3-(2-bromo-3,5-difluoropyridin-4-yl)propanoic acid; propyl 2-amino-3-(2-bromo-3,5-difluoropyridin-4-yl)propanoate; 2-amino-3-[(2-bromopyridine-4-sulfonyl)amino]propanoic acid; propyl 2-amino-3-[(2-bromopyridine-4-sulfonyl)amino]propanoate; ethyl 2-amino-3-(5,6-dibromopyridin-3-yl)propanoate; ethyl 2-amino-3-(2,3-dibromopyridin-4-yl)propanoate acid; 2-amino-3-[2-chloro-5-(trifluoromethyl)pyridin-3-yl]propanoic acid; 2-amino-3-(2-amino-6-oxo-1,6-dihydropyrimidin-5-yl)propanoic acid; 2-amino-3-(6-hydroxy-5-nitropyridin-3-yl)propanoic acid; methyl 2-amino-3-(2-bromopyridin-4-yl)propanoate; 3-(2-amino-2-carboxyethyl)-1-methylpyridin-1-ium; 3-(2-amino-2-carboxyethyl)-1-hydroxypyridin-1-ium; 2-amino-3-(4-amino-6-hydroxy-2-methylpyrimidin-5-yl)propanoic acid; methyl 2-amino-3-(2,6-dibromopyridin-4-yl)propanoate; ethyl 3-(6-bromopyridin-3-yl)-2-acetamidopropanoate; methyl 3-(6-bromopyridin-3-yl)-2-acetamidopropanoate; ethyl-2-acetamido-3-(2-methoxypyrimidin-4-yl)propanoate; 2-(2-methoxyethoxy)ethyl 2-amino-3-(6-bromopyridin-3-yl)propanoate; 2-(2-ethoxyethoxy)ethyl 2-amino-3-(6-bromopyridin-3-yl)propanoate; 5-(2-amino-2-carboxyethyl)-1-methylpyrimidin-1-ium; 2-amino-3-[2-(trifluoromethyl)pyridin-4-yl]propanoic acid hydrochloride[HCl]; ethyl 3-[(2-bromopyridin-4-yl)oxy]-2-acetamidopropanoate; ethyl 2-acetamido-3-(pyridin-4-yloxy)propanoate; 2-amino-4-(1H-pyrrol-3-yl)butanoic acid; 2-amino-3-(1H-pyrrol-2-yl)propanoic acid; 2-amino-3-(1H-pyrrol-3-yl)propanoic acid; 2-amino-3-(4H-1,2,4-triazol-3-yl)propanoic acid; (2S)-2-hydroxy-3-(1H-imidazol-4-yl)propanoic acid; ethyl 2-[[(benzyloxy) carbonyl]amino]-3-(1H-1,2,4-triazol-3-yl)propanoate; 2-amino-3-(4-methyl-4H-1,2,4-triazol-3-yl)propanoic acid; 2-amino-3-(1-methyl-1H-1,2,4-triazol-5-yl)propanoic acid dihydrochloride; 2-amino-3-(1-methyl-1H-1,2,3-triazol-4-yl)propanoic acid hydrochloride; 2-amino-3-(2-methyl-2H-1,2,3,4-tetrazol-5-yl)propanoic acid hydrochloride;

2-amino-3-(dimethyl-4H-1,2,4-triazol-3-yl)propanoic acid hydrochloride; (2S)-2-amino-3-[5-(trifluoromethyl)-1H-pyrazol-4-yl]propanoic acid; and 2-(2-butoxyethoxy)ethyl 2-amino-3-(2H-1,2,3-triazol-4-yl)propanoate; and, b) a second herbicide.

- 5 According to some embodiments, the invention provides a mixture comprising: a) a compound selected from the group consisting of 2-amino-3-(thiophen-2-yl)propanoic acid; 2-amino-3-(thiophen-3-yl)propanoic acid; 2-amino-3-[(thiophene-3-sulfonyl)amino]propanoic acid; 2-amino-3-[(4-fluorothiophene-3-sulfonyl)amino]propanoic acid; methyl 2-amino-3-[(thiophene-3-sulfonyl)amino]propanoate; pentyl 2-amino-3-[(thiophene-3-sulfonyl)amino]propanoate; 3-(5-cyano-3-thienyl)alanine; 2-amino-3-[4-(trifluoromethyl)thiophen-2-yl]propanoic acid; 3-amino-3-(4-bromothiophen-3-yl)propanoic acid; 2-amino-3-(2,4,5-trimethylthiophen-3-yl)propanoic acid; butyl 2-amino-3-(thiophen-3-yl)propanoate; 2-amino-3-[(2,5-dichlorothiophene-3-sulfonyl)amino]propanoic acid; 2-amino-3-[(2,5-dichloro-4-methylthiophene-3-sulfonyl)amino]propanoic acid; 2-amino-3-(2-chlorothiophen-3-yl)propanoic acid; 2-amino-3-(2,5-dichlorothiophen-3-yl)propanoic acid; 2-amino-3-(5-chlorothiophen-3-yl)propanoic acid; 2-amino-3-(2,5-dihydro-1,3-thiazol-4-yl)propanoic acid; 2-amino-3-(1,3-thiazol-5-yl)propanoic acid; 2-amino-3-[[2,5-dichloro-4-(trifluoromethyl)thiophene-3-sulfonyl]amino]propanoic acid; 2-amino-3-(2-amino-1,3-thiazol-4-yl)propanoic acid; methyl 2-amino-3-[(2,5-dichlorothiophene-3-sulfonyl)amino]propanoate; ethyl 2-amino-3-[(2,5-dichlorothiophene-3-sulfonyl)amino]propanoate; 2-propoxyethyl-2-amino-3-[(2,5-dichlorothiophene-3-sulfonyl)amino]propanoate; [2-(carboxyamino)-3-ethoxy-3-oxopropyl] (2,5-dichlorothiophene-3-sulfonyl)carbamic acid; 2-amino-3-(2,5-dichloro-1,3-thiazol-4-yl)propanoic acid; 2-amino-3-(5-chloro-1,3-thiazol-4-yl)propanoic acid; 2-amino-3-(1,2,5-thiadiazol-3-yl)propanoic acid; 2-amino-3-(1,2,4-thiadiazol-5-yl)propanoic acid; 2-amino-

3-(furan-3-yl)propanoic acid; 2-amino-3-(1,3-oxazol-4-yl)propanoic acid; 2-formamido-3-(thiophen-3-yl)propanoic acid; methyl 2-amino-3-(thiophen-3-yl)propanoate; ethyl 2-amino-3-(thiophen-3-yl)propanoate; [2-amino-3-(thiophen-3-yl)propanamido]acetic acid; 2-amino-N-[2-(2-hydroxyethoxy)ethyl]-3-(thiophen-3-yl)propenamide; ethyl 2-butanamido-3-(dichloro-1,3-thiazol-4-yl)propanoate; 2-butoxyethyl 2-acetamido-3-(2,5-dichloro-1,3-thiazol-4-yl)propanoate; 2-amino-3-(2,5-dibromothiophen-3-yl)propanoic acid; 2-amino-3-(5-nitrothiophen-3-yl)propanoic acid; butyl 3-(dichloro-1,3-thiazol-4-yl)-2-acetamidopropanoate; 2-ethoxyethyl 3-(dichloro-1,3-thiazol-4-yl)-2-acetamidopropanoate; 2-amino-3-[5-(trifluoromethyl)thiophen-3-yl]propanoic acid; (2S)-2-amino-3-(3,5-dioxo-1,2,4-oxadiazolidin-2-yl)propanoic acid; 2-amino-3-[(2,5-dibromothiophene-3-sulfonyl)amino]propanoic acid; 2-amino-3-(5-chloro-2-methylthiophen-3-yl)propanoic acid; 2-amino-3-(2-bromothiophen-3-yl)propanoic acid; 2-amino-3-(1,1-dioxo-1H-6-thiolan-3-yl)propanoic acid; 2-amino-3-(thiolan-3-yl)propanoic acid; [2-amino-2-(thiophen-3-yl)ethyl]phosphonic acid; 2-amino-3-(2,5-dimethyl-1,1-dioxo-1H-6-thiophen-3-yl)propanoic acid; 3-(2,5-dioxo-2,5-dihydrothiophen-3-yl)-2-(phosphonoamino)propanoic acid; 2-amino-3-[4-(trifluoromethyl)thiophen-3-yl]propanoic acid; ethyl 2-acetamido-3-(2,5-dichloro-1,3-thiazol-4-yl)propanoate; methyl 2-amino-3-(2,5-dichlorothiophen-3-yl)propanoate; ethyl 2-amino-3-(2,5-dichlorothiophen-3-yl)propanoate; 2-(2-methoxyethoxy)ethyl-2-amino-3-(thiophen-3-yl)propanoate; ethyl 2-acetamido-3-(thiophen-3-yl)propanoate; ethyl 3-(2,5-dichlorothiophen-3-yl)-2-acetamidopropanoate; ethyl 3-(2,5-dichlorofuran-3-yl)-2-acetamidopropanoate; propyl 2-amino-3-(2,5-dichlorofuran-3-yl)propanoate; 4-(2-acetamido-3-ethoxy-3-oxopropyl)-3-methyl-1,3-thiazol-3-ium chloride; 2-(2-ethoxyethoxy)ethyl 3-(2,5-dichlorothiophen-3-yl)-2-

acetamidopropanoate; pentyl 2-acetamido-3-(1,3,4-oxadiazol-2-yl)propanoate; ethyl-2-amino-3-[(2,5-dibromothiophene-3-sulfonyl)amino]propanoate; butyl 3-(5-chloro-1,2,4-thiadiazol-3-yl)-2-acetamidopropanoate; 2-amino-3-(1H-indazol-3-yl)propanoic acid hydrochloride[HCl]; 2-amino-3-(pyridazin-4-yl)propanoic acid; 2-amino-3-(pyridin-4-yl)propanoic acid; 2-amino-3-(pyridin-3-yl)propanoic acid dihydrochloride

3-(5-Hydroxy-3-pyridinyl)alanine; 2-amino-3-(5-methylpyridin-3-yl)propanoic acid; 2-amino-3-(4-aminopyridin-2-yl)propanoic acid; 2-amino-3-(2-aminopyridin-4-yl)propanoic acid; 2-amino-3-(6-aminopyridin-2-yl)propanoic acid; 2-amino-3-(5-aminopyridin-3-yl)propanoic acid; 2-amino-3-(5-sulfanylpiperidin-3-yl)propanoic acid; 2-amino-3-(2-sulfanylpiperidin-4-yl)propanoic acid; 2-amino-3-(pyrimidin-5-yl)propanoic acid; 2-amino-3-(4-amino-6-chloropyrimidin-2-yl)propanoic acid; 2-amino-3-(pyrimidin-2-yl)propanoic acid dihydrochloride; 2-amino-3-(4-hydroxypyrimidin-2-yl)propanoic acid; 2-amino-3-(2,4-dioxo-1,2,3,4-tetrahydropyrimidin-5-yl)propanoic acid; 2-amino-3-(pyrazin-2-yl)propanoic acid; 2-amino-3-(5-chloropyridin-3-yl)propanoic acid; 2-amino-3-(2,5-dichloropyridin-3-yl)propanoic acid; 2-amino-3-(pyrimidin-4-yl)propanoic acid; 2-amino-3-(5-fluoropyridin-3-yl)propanoic acid; 2-amino-3-(6-chloropyridin-3-yl)propanoic acid; 2-amino-3-(2,6-dichloropyridin-4-yl)propanoic acid; 2-amino-3-(3,5-dichloropyridin-4-yl)propanoic acid; 2-amino-3-(3,5-difluoropyridin-4-yl)propanoic acid; 2-amino-3-[2-(dimethylamino)pyridin-4-yl]propanoic acid; 2-amino-3-(2-bromopyridin-4-yl)propanoic acid; 2-amino-3-(5,6-dibromopyridin-3-yl)propanoic acid; 2-amino-3-(2,6-dibromopyridin-4-yl)propanoic acid; 2-amino-3-(2,3-dibromopyridin-4-yl)propanoic acid; 2-amino-3-[5-(trifluoromethyl)pyridin-3-yl]propanoic acid; 2-amino-3-(5,6-dichloropyridin-3-yl)propanoic acid; 2-amino-3-(2-oxo-1,2-dihydropyridin-4-yl)propanoic acid; 2-amino-3-[4-

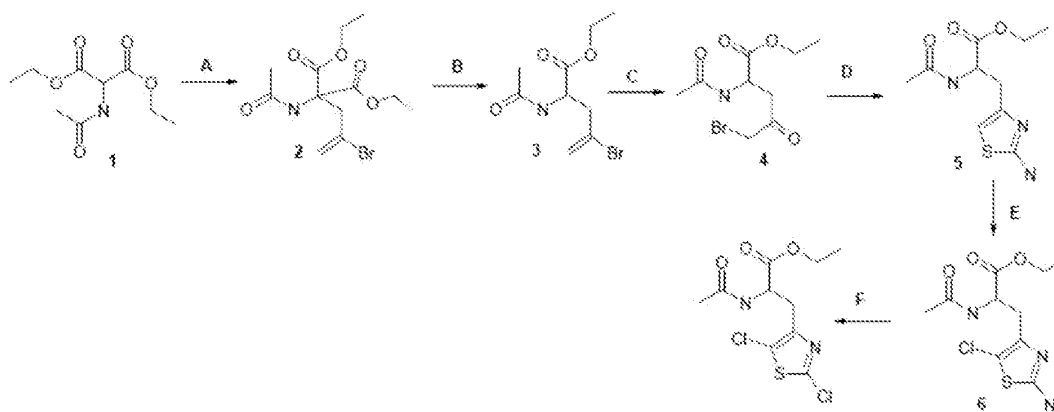
(dimethylamino)pyridin-3-yl]propanoic acid; 2-amino-3-(2-oxo-1,2-dihydropyridin-3-yl)propanoic acid; 2-amino-3-(6-oxo-1,6-dihydropyrimidin-4-yl)propanoic acid; 2-amino-3-(6-oxo-1,6-dihydropyrimidin-5-yl)propanoic acid; 2-amino-3-(6-oxo-1,6-dihydropyridin-3-yl)propanoic acid; 2-amino-3-(2,6-dioxo-1,2,3,6-tetrahydropyrimidin-4-yl)propanoic acid; 2-amino-3-(6-oxo-2-sulfanyl-1,6-dihydropyrimidin-4-yl)propanoic acid; propyl 2-amino-3-(2-bromopyridin-4-yl)propanoate; 2-amino-3-(2-bromo-3,5-difluoropyridin-4-yl)propanoic acid; propyl 2-amino-3-(2-bromo-3,5-difluoropyridin-4-yl)propanoate; 2-amino-3-[(2-bromopyridine-4-sulfonyl)amino]propanoic acid; propyl 2-amino-3-[(2-bromopyridine-4-sulfonyl)amino]propanoate; ethyl 2-amino-3-(5,6-dibromopyridin-3-yl)propanoate; ethyl 2-amino-3-(2,3-dibromopyridin-4-yl)propanoate acid; 2-amino-3-[2-chloro-5-(trifluoromethyl)pyridin-3-yl]propanoic acid; 2-amino-3-(2-amino-6-oxo-1,6-dihydropyrimidin-5-yl)propanoic acid; 2-amino-3-(6-hydroxy-5-nitropyridin-3-yl)propanoic acid; methyl 2-amino-3-(2-bromopyridin-4-yl)propanoate; 3-(2-amino-2-carboxyethyl)-1-methylpyridin-1-ium; 3-(2-amino-2-carboxyethyl)-1-hydroxypyridin-1-ium; 2-amino-3-(4-amino-6-hydroxy-2-methylpyrimidin-5-yl)propanoic acid; methyl 2-amino-3-(2,6-dibromopyridin-4-yl)propanoate; ethyl 3-(6-bromopyridin-3-yl)-2-acetamidopropanoate; methyl 3-(6-bromopyridin-3-yl)-2-acetamidopropanoate; ethyl-2-acetamido-3-(2-methoxypyrimidin-4-yl)propanoate; 2-(2-methoxyethoxy)ethyl 2-amino-3-(6-bromopyridin-3-yl)propanoate; 2-(2-ethoxyethoxy)ethyl 2-amino-3-(6-bromopyridin-3-yl)propanoate; 5-(2-amino-2-carboxyethyl)-1-methylpyrimidin-1-ium; 2-amino-3-[2-(trifluoromethyl)pyridin-4-yl]propanoic acid hydrochloride[HCl]; ethyl 3-[(2-bromopyridin-4-yl)oxy]-2-acetamidopropanoate; ethyl 2-acetamido-3-(pyridin-4-yloxy)propanoate; 2-amino-4-(1H-pyrrol-3-yl)butanoic acid; 2-amino-3-(1H-pyrrol-2-yl)propanoic acid; 2-amino-3-(1H-pyrrol-3-yl)propanoic acid; 2-amino-3-(4H-1,2,4-triazol-3-yl)propanoic

acid; (2S)-2-hydroxy-3-(1H-imidazol-4-yl)propanoic acid; ethyl
 2-[[(benzyloxy) carbonyl] amino]-3-(1H-1,2,4-triazol-3-
 yl)propanoate; 2-amino-3-(4-methyl-4H-1,2,4-triazol-3-
 yl)propanoic acid; 2-amino-3-(1-methyl-1H-1,2,4-triazol-5-
 5 yl)propanoic acid dihydrochloride; 2-amino-3-(1-methyl-1H-
 1,2,3-triazol-4-yl)propanoic acid hydrochloride; 2-amino-3-(2-
 methyl-2H-1,2,3,4-tetrazol-5-yl)propanoic acid hydrochloride;
 2-amino-3-(dimethyl-4H-1,2,4-triazol-3-yl)propanoic acid
 hydrochloride; (2S)-2-amino-3-[5-(trifluoromethyl)-1H-pyrazol-
 10 4-yl]propanoic acid; and 2-(2-butoxyethoxy)ethyl 2-amino-3-(2H-
 1,2,3-triazol-4-yl)propanoate; and b) a plant growth regulator.

Examples

In the examples below, if an abbreviation is not defined above,
 it has its generally accepted meaning. Further, all temperatures
 15 are in degrees Celsius (unless otherwise indicated). The
 following methods were used to prepare the compounds set forth
 below as indicated.

Example 1: Synthesis of ethyl 2-acetamido-3-(2,5-dichloro-1,3-thiazol-4-yl)propanoate (Code 567)



Step A: To a stirred mixture of NaH (44 g, 1.1 mol, 60% in
 20 silicone oil) in dry DMF (2.50 L) diethyl acetamidomalonate 1
 (217 g, 1.0 mol) was added 2,3-dibromopropene (240 g, 1.2 mol).
 The reaction mixture was stirred at room temperature overnight
 to yield diethyl 2-acetamido-2-(2-bromoallyl) malonate. After

completion of the reaction (confirmed by HNMR) the reaction mixture was used in the Step B.

Step B: To a solution of diethyl 2-acetamido-2-(2-bromoallyl)malonate obtained at the Step A, 336 g) water (45 mL, 2.5 mol) and LiBr (102 g, 1.2 mol) were subsequently added and the mixture was heated to reflux under argon for 6 h. The mixture was subsequently evaporated to remove DMF and quenched with EtOAc (1.5 L) and H₂O (1 L). The mixture was stirred for 10 min and extracted with EtOAc (3 × 0.5 L), the combined organic layers were washed with brine (3 × 0.5 L), dried over Na₂SO₄ anhydride) and concentrated in vacuo. Obtained oily residue (210 g, 93% purity) was used in the next step without purification.

Step C: To a cold (0°C) stirred solution of 3 (210 g, 93% purity, 0.74 mol), under nitrogen, in a 2:1 mixture of acetonitrile/water (1.68 L) was added solid N-bromosuccinimide (193 g, 1.08 mole) in three portions over a period of 15 min. The resultant orange mixture was stirred at 0°C for 1 h. The reaction mixture was treated at RT with 10% of aqueous sodium thiosulfate in ethyl acetate (1.5 L) and washed with water (4 × 300 mL) and brine (4 × 300 mL). Evaporation of the organic solvents results in the compound 4 (122 g, 0.43 mol) which was used in the next step without purification.

Step D: Compound 4 (122 g, 0.43 mol) and thiourea (33 g, 0.44 mol) were dissolved in EtOH (1.5 L) and stirred under reflux overnight. After the reaction was complete (confirmed by HNMR), the organic solvents were evaporated, and the crude residue was partitioned in EtOAc/H₂O (1 L:1 L). The lower layer was carefully basified with 10% aq NaOH to pH=9 and extracted with CH₂Cl₂ (3 × 150 mL). Combined organic layers was washed with brine (2 × 100 mL), dried over Na₂SO₄ anhydride and evaporated, compound 5 (80 g, 0.28 mol)

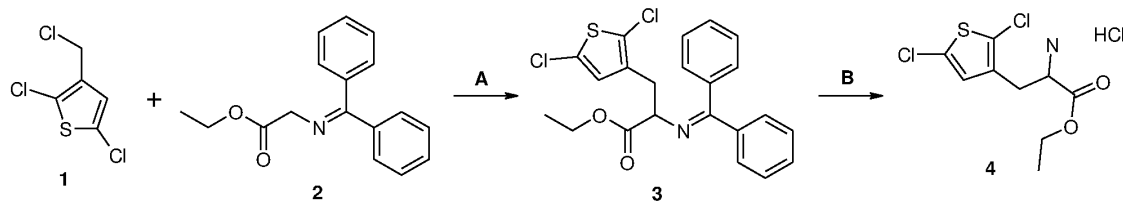
Step E: Compound 5 (80 g, 0.28 mol) and N-chlorosuccinimide (56 g, 0.42 mol) were dissolved in acetonitrile (1.5 L). The mixture

was stirred at ambient temperature for one hour. After the completion of the reaction, acetonitrile was evaporated under reduced pressure and the residue was partitioned in water/ ethyl acetate (400 mL : 400 mL). The layers were separated, and the aqueous layer was extracted with ethyl acetate (3 × 150 mL). The combined organic layers were washed with brine, dried over sodium sulfate, filtered and concentrated to give compound 6 (60 g, crude, 70% purity) which was used immediately in the next step without purification.

- Step F: To a round bottomed flask was added crude compound 6 (60 g, crude, 70% purity), copper (II) chloride (38 g, 0.28 mol), and tert-butyl nitrite (35.6 mL, 0.3 mol) in CH₃CN (1 L). The mixture was heated to 40° C for 2 hours, then the mixture was diluted with 1N HCl and extracted with EtOAc. The organic extract was washed with water (2 × 100 mL), brine (2 × 100 mL), dried over Na₂SO₄ anhydride, filtered and concentrated in vacuo to give the title compound, which was purified by CC to 95% purity (5.5 g, 0.018 mol).

Analytical data: ¹H NMR (400 MHz, CDCl₃) δ 6.42 (s, 1H), 4.99 – 4.75 (m, 1H), 4.17 (q, J = 6.7 Hz, 2H), 3.30 – 2.99 (m, 2H), 2.00 (s, 1H), 1.24 (t, J = 7.1 Hz, 3H); ESI: Calculated [M+]⁺ (C₁₀H₁₂O₃SN₂Cl₂) m/z: 311 AND 313. Found [M-e]⁺, 311 and 312.9 [M+Cl]⁻=346,8 and 348.7

Example 2: Synthesis of ethyl 2-amino-3-(2,5-dichlorothiophen-3-yl)propanoate (Code 569)



25

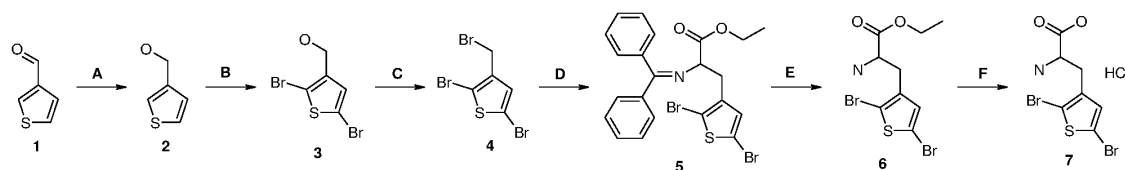
Step A. To a flame-dried flask containing t-BuOK (12.3 g, 109 mmol, 1.10 eq.) and anhydrous DMF (900 ml) was added ethyl 2-

((diphenylmethylene)amino) acetate **2** (27.9 g, 104 mmol, 1.05 eq.) at 0 °C under argon. After 10 min, chloride **1** (20 g, 99 mmol, 1.0 eq.) was added. The resulting reaction mixture was stirred at 0 °C for 10 min and then at RT overnight. The reaction mixture was then slowly poured into water, extracted with DCM. The combined organic layers were dried over Na₂SO₄ anhydride, filtered and concentrated under reduced pressure to give compound **3** (29.0 g, 67.6%).

Step B. Compound **3** (29.0 g, 67 mmol) was treated with a mixture of EtOH/concentrated HCl (25:1 v/v) (700 ml). The resulting solution was stirred at room temperature for 2 h. After evaporation of the solvent the residue was rinsed with water, washed with hexane and concentrated under reduced pressure to yield the target product (16.9 g, 83.0%).

Analytical data: ¹H NMR (DMSO-d₆) δ_H (ppm): 1.12 (t, 3H, CH₃), 3.02–3.14 (dd, 2H, CH₂), 4.07–4.16 (m, 2H, CH₂), 4.20–4.26 (m, 1H, CH), 7.20 (s, 1H, HetAr.H), 8.67–8.78 (br.s, 3H, NH₂.HCl) ESI: Calculated [M+] (C₉H₁₁O₂NSCl₂) m/z: 268.0 and 270.0. Found [M-e]⁺, 268.0 and 270.0

Example 3: Synthesis of 2-amino-3-(2,5-dibromothiophen-3-yl)propanoic acid (Code 552)



A. Sodium borohydride (2.0 g, 53 mmol, 0.5 eq.) was added to a solution of aldehyde **1** (12.0 g, 107 mmol, 1 eq.) in methanol (150 ml) at 0°C. The reaction mixture was stirred 4 hours at room temperature and then partitioned in 5% HCl (300 mL)/ and ethyl acetate (150 mL). The aqueous layer was separated and extracted with ethyl acetate (2 x 150 ml). The combined organic

phases were dried over Na₂SO₄, filtered and concentrated to dryness to give the product **2** (10.1 g, 83%)

B. NBS (30.7 g, 173 mmol, 1.95 eq.) was added gradually to compound **2** (10.1 g, 88 mmol, 1 eq.) in THF (300 mL) and the mixture was kept at RT overnight, filtered, and then THF was removed by rotary evaporation. The product was dissolved in diethyl ether, then rinsed with 1M sodium hydroxide solution and water. The organic layer was dried over Na₂SO₄ and the product was eluted over silica gel using hexane: ethyl acetate (80:20). The solvent was removed by rotary evaporation to yield the desired product **3** (18.5 g, 77% yield).

C. Compound **3** (17.3 g, 64 mmol, 1 eq.) in DCM (200 mL) was added to a 500 ml flask, and the flask was placed in an ice water bath. Phosphorus tribromide (6.6 ml, 70 mmol, 1.1 eq.) was added dropwise to the solution. The reaction was run at room temperature for 5 h, then quenched with a 10% sodium bicarbonate solution. The organic solution was washed with water, dried over Na₂SO₄ anhydride and concentrated under reduced pressure to give compound **4** (18.5 g, 87% yield).

D. To a flame-dried flask containing t-BuOK (6.8 g, 61 mmol, 1.10 eq.) and anhydrous DMF (500 ml) was added ethyl 2-((diphenylmethylene)amino)acetate **2** (15.5 g, 58 mmol, 1.05 eq.) at 0 °C under argon. After 10 min, bromide **4** (18.5 g, 55 mmol, 1.0 eq.) was added. The resulting reaction mixture was stirred at 0 °C for 10 min and was allowed to warm up to room temperature and stirred overnight, then slowly poured into water, extracted with DCM. The combined organic layers were dried over Na₂SO₄ anhydride, filtered and concentrated under reduced pressure to give compound **5** (21.3 g, 74%).

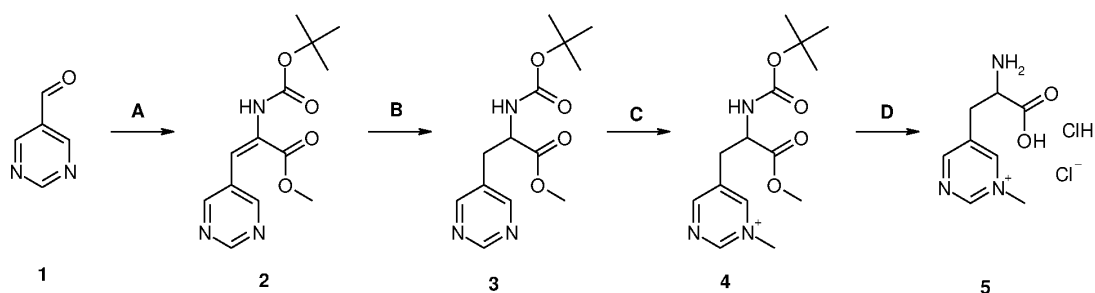
E. Compound **5** (21.3 g, 41 mmol) was treated with a mixture of EtOH/concentrated HCl (25:1 v/v) (400 ml). The resulting solution was stirred at room temperature for 2 h. Upon the evaporation of solvent, the residue was basified by 2N K₂CO₃ solution to pH >10

and extracted with DCM. The combined organic layers were dried over Na₂SO₄, filtered and concentrated under reduced pressure. The residue was purified by flash chromatography on silica gel (1:20 CH₃OH/DCM) to produce the product 6 (11.0 g, 75%).

F. Product 6 (11.0 g, 31 mmol) was dissolved in 3N hydrochloric acid (250 ml). The mixture was stirred at 70°C for 12 h. The solvent was evaporated under reduced pressure to give the title compound (11.25 g, 99%).

Analytical data: ¹H NMR (DMSO-d₆) δ_H (ppm): 3.08 (m, 2H, CH₂), 4.05 (t, 1H, CH), 7.24 (s, 1H, HetAr.H); 8.2-9.1 (br.s, 2H, NH₂); ESI: Calculated [M⁺] (C₇H₇O₂NSBr₂) m/z: 328.86. Found [M+H⁺]=329.8 and 327.8, [M-H⁺], 327.80 and 325.8.0

Example 4: Synthesis of 5-(2-amino-2-carboxyethyl)-1-methylpyrimidin-1-ium (Code 676)



A. Compound 1 and methyl 2-((tert-butoxy)carbonylamino)-2-(dimethyl phosphonoacetate) (1.2 eq) were dissolved in DCM. Then reaction mixture was cooled and 2H, 3H, 4H, 6H, 7H, 8H, 9H, 10H-pyrimido[1,2-a]azepine (1.4 eq) was slowly added. The reaction was stirred overnight at RT. After that it was washed with water (3 times) and brine, dried over Na₂SO₄ anhydride and evaporated to produce crude compound 2.

B. Compound 2 in MeOH was added to Pd/C, 5% (0.1 eq). The reaction mixture was stirred at RT overnight in H₂ atmosphere, filtered and resulting solution was evaporated to produce crude

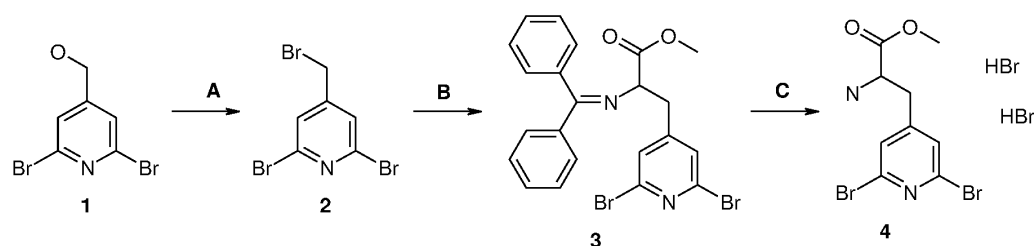
compound 3. Crude compound 3 purified with column chromatography (Hex-EtOAc was used as an eluent mixture).

C. Compound 3 was dissolved in MeCN and MeI (7 eq) was added dropwise. The reaction was stirred at RT overnight. After that it was evaporated to produce crude compound 4 which was used in next step without further purification.

D. Compound 4 was dissolved in HCl/dioxane and the reaction was refluxed overnight. After that it was evaporated to afford crude compound 5 which was stirred with MeCN and filtered on, dried to afford target compound.

Analytical data: ^1H NMR(DMSO- d_6), δ_{H} (ppm): 3.40-3.60 (d, 2H, CH_2), 4.50-4.60 (br.s, 1H, CH), 8.80-8.95(br.s, 3H, CH_3), 9.40(s, 1H, PyrH), 9.65 (s, 1H, PyrH), 9.70 (s, 1H, PyrH). ^{13}C NMR (DMSO- d_6) δ_{H} (ppm): 30.12(CH_2), 45.5(CH_3), 52.3(CH), 132.2(PyrCq), 153.0(PyrCH), 154.3(PyrCH), 165.0 (PyrCH), 169.8 (COOH). ESI: Calculated $[\text{M}^+]$ ($\text{C}_8\text{H}_{12}\text{O}_2\text{N}_3$) m/z : 182.0. Found $[\text{M}-\text{e}]^+$, 182.0

Example 5: Synthesis of methyl 2-amino-3-(2,6-dibromopyridin-4-yl)propanoate (Code 670)



A. Compound 1 (16.0 g, 60 mmol, 1 eq.) in DCM (200 mL) was added to a 500 ml flask, and the flask was placed in an ice water bath. Phosphorus tribromide (6.8 ml, 72 mmol, 1.2 eq.) was added dropwise to the solution. The reaction was run at room temperature for 5 h, then quenched with a 10% sodium bicarbonate solution. The organic solution was washed with water, dried over

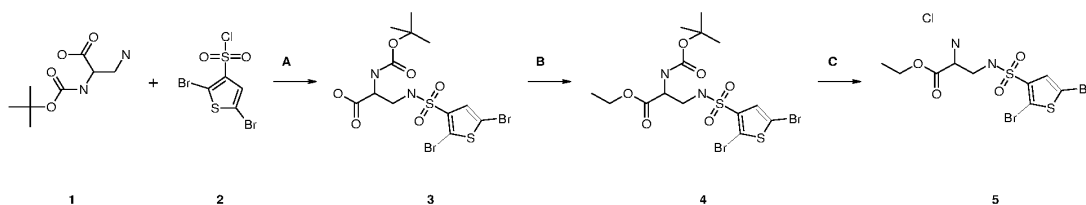
Na₂SO₄ and concentrated under reduced pressure to give compound **2** (18.5 g, 94.0% yield).

B. To a flame-dried flask containing t-BuOK (6.9 g, 62 mmol, 1.10 eq.) and anhydrous DMF (500 ml) was added methyl 2-((diphenylmethylene)amino) acetate (14.9 g, 59 mmol, 1.05 eq.) at 0 °C under argon. After 10 min, bromide **2** (18.5 g, 55 mmol, 1.0 eq.) was added. The resulting reaction mixture was stirred at 0 °C for 10 min and was allowed to warm up to room temperature and stirred overnight. The reaction mixture was then slowly poured into water, extracted with DCM. The combined organic layers were dried over Na₂SO₄ anhydride, filtered and concentrated under reduced pressure to give compound **3** (24.5 g, 87.0%).

C. Compound **3** (24.5 g, 49 mmol) was treated with a mixture of EtOH/48% HBr (25:1 v/v) (600 ml). The resulting solution was stirred at room temperature for 2 h. After evaporation of solvent the residue was rinsed with water, washed with hexane and concentrated under reduced pressure to produce the target product **4** (19.7 g, 81.0%).

Analytical data: ¹H NMR (DMSO-d₆), δ_H (ppm): 3.00–3.10 (m, 1H, CH₂), 3.15–3.23 (m, 1H, CH₂), 3.75 (s, 3H, CH₃), 4.50–4.58 (t, 1H, CH), 7.70 (s, 2H, PyrH), 8.30–8.40 (br.s, 3H, NH₂.H⁺); ESI: Calculated [M⁺] (C₉H₁₀O₂N₂Br₂) m/z: 338.0 (Br 79 and 81). Found [M-e]⁺, 339.0 and 341.0

Example 6: Synthesis of ethyl 2-amino-3-[(2,5-dibromothiophene-3-sulfonyl)amino]propanoate (Code 580)



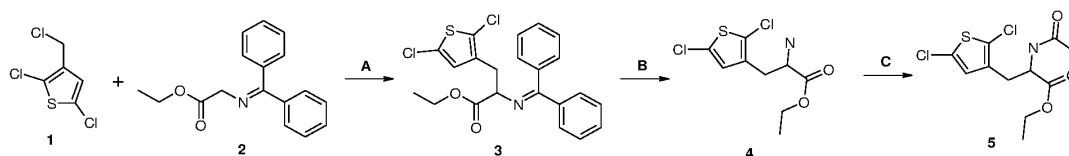
Step A N-Boc-3-amino-alanine **1** (50 g, 0.23 mol, 2.3 eq) was suspended in 2 l of dry acetone in the flame dried 4 l flask

under argon. Then, TEA (70 ml, 0,5 mol, 5,1 eq) was added and reaction mixture stirred for 30 minutes at RT. Compound 2 was dissolved in dry acetone and dropped into the reaction mixture at -5-+5 °C. Reaction mixture was stirred at RT overnight. Then reaction mixture was poured to the ice, acidified with water solution of citric acid and extracted with ethyl acetate (5x500 ml). Combined organic layers were washed with water (2x200 ml), dried over Na_2SO_4 anhydride and evaporated under reduced pressure. Obtained crude compound 3 was purified by column chromatography. Mass of isolated product 3 (90 % purity) (9 g, yield 18%).

Step B. DCC (2,6 g 0,0124 mol, 1,1 eq) and DMAP (0.014 g 0,00114 mol, 0,01 eq), were treated with solution of sulfamide 3 (5,8 g, 0,0114 mol, 1 eq) in 500 ml of dry methylene chloride in the flame dried 1 l 3-neck flask. After that, dry ethanol (~2 ml, 0,022 mol, ~2 eq) was added to the reaction mixture. Reaction mixture was stirred at RT overnight. Then reaction mixture was evaporated under reduced pressure. Water was added to the residue and target compound was extracted with ethyl acetate. Combined organic layers were dried Na_2SO_4 and evaporated. Crude compound was purified by column chromatography (Yield 2,5 g of 90% purity of target compound, 40% yield).

Step C. HCl \dioxane (100ml) was added to the sulfamide 4 (2,5 g, 0,0046 mol, 1 eq) dissolved in 20 ml of dry chloroform in the flame dried 250 ml flask. Reaction mixture stirred overnight. Solvent was evaporated. The target compound was purified by HPLC. Yield 0,7959 g (~36%).

Analytical data: Solid ^1H NMR δH (ppm): 1.28-1.37(t, 3H, CH_3), 3.35-3.45(m, 1H, CH_2), 3.51-3.55(m, 1H, CH_2), 4.04-4.07(br.s, 1H, CH), 4.20-4.30(m, 2H, CH_2), 7.30(s, 1H, Thiop.H); ESI: Calculated $[\text{M}]^+$ ($\text{C}_9\text{H}_{12}\text{O}_4\text{N}_2\text{S}_2\text{Br}_2$) $m/z=404$ (Br 79/81) and 406 (Br=81). Found $[\text{M}+\text{H}]^+=406.8$ (Br=79/81) and 468.8 (Br81/81).

Example 7: Synthesis of ethyl 3-(2,5-dichlorothiophen-3-yl)-2-acetamidopropanoate (Code 573)

A. To a flame-dried flask containing t-BuOK (9.2 g, 82 mmol, 1.10 eq.) and anhydrous DMF (700 ml) was added ethyl 2-((diphenylmethylene)amino) acetate 2 (20.9 g, 78 mmol, 1.05 eq.) at 0 °C under argon. After 10 min, chloride 1 (15 g, 74 mmol, 1.0 eq.) was added. The resulting reaction mixture was stirred at 0 °C for 10 min and then the mixture was stirred overnight at RT. The reaction mixture was then slowly poured into water, extracted with DCM. The combined organic layers were dried over Na_2SO_4 anhydride, filtered and concentrated under reduced pressure to give compound 3 (21 g, 65.2%).

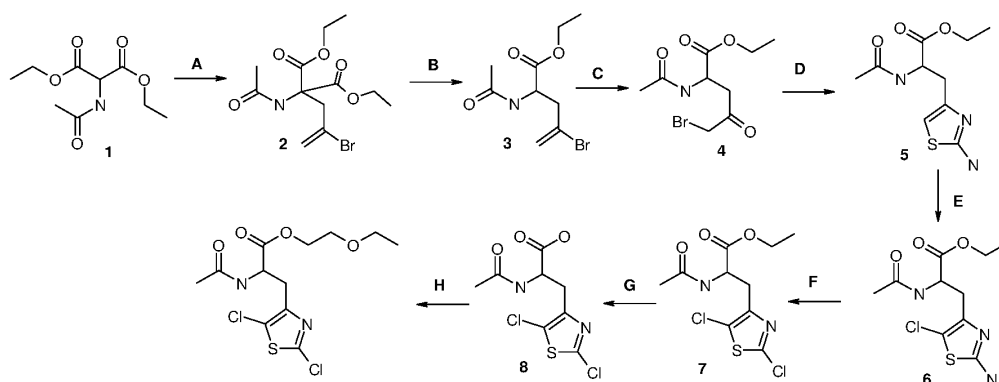
B. Compound 3 (21.0 g, 49 mmol) was treated with a mixture of EtOH/concentrated HCl (25:1 v/v) (500 ml). The resulting solution was stirred at room temperature for 2 h. Upon the evaporation of solvent, the residue was basified by 2N K_2CO_3 solution to pH >10 and extracted with DCM. The combined organic layers were dried over Na_2SO_4 , filtered and concentrated under reduced pressure. The residue was purified by flash chromatography on silica gel (1:20 $\text{CH}_3\text{OH}/\text{DCM}$) to give compound 4 (12.7 g, 86%).

C. To a stirred solution of compound 4 (12.7 g, 47 mmol, 1.0 eq.) in 300 mL of DCM was added 13.2 ml (95 mmol, 2 eq.) of TEA followed by 4.9 ml (52 mmol, 1.1 eq.) of acetic anhydride. The reaction mixture was stirred at room temperature for 12 h. The reaction mixture was then diluted with 150 ml of NaHCO_3 and extracted with DCM. The combined organic layers were dried over Na_2SO_4 , filtered and concentrated under reduced pressure. The

residue was purified by flash chromatography on silica gel (1:4 EtOAc/Hexane) to give compound 5 (13.3 g, 91%).

Analytical data: ^1H NMR (400MHz, CDCl_3) δ_{H} (ppm): 1.2-1.3 (t, 3H, CH_3), 1.95 (s, 3H, CH_3), 2.95-3.10 (dd, 2H, CH_2 -thiophen), 4.10-4.25 (m, 2H, CH_2 -ethyl), 4.75-4.80 (d, 1H, CH), 6.00 (s, 1H, H-thiophen), 6.60 (s, 1H, NH); ESI: Calculated $[\text{M}^+]$ ($\text{C}_{11}\text{H}_{13}\text{O}_3\text{NSCl}_2$) m/z : 310.0 and 312.0. Found $[\text{M}-\text{e}]^+$, 310.0 and 312.0

Example 8: Synthesis of 2-ethoxyethyl 3-(dichloro-1,3-thiazol-4-yl)-2-acetamidopropanoate (Code 555)



5

To a stirred mixture of NaH (44 g, 1.1 mol, 60% in silicone oil) in dry DMF (2.50 L) were added diethyl acetamidomalonate **1** (217 g, 1.0 mol) and 2,3-dibromopropene (240 g, 1.2 mol). The reaction mixture was stirred at room temperature overnight. After the reaction was complete (controlled by HNMR) the mixture was used in the next step without quenching.

B. To a soln of diethyl 2-acetamido-2-(2-bromoallyl)malonate **2** (336 g) in DMF (2.5 L) H_2O (45 mL, 2.5 mol) and LiBr (102 g, 1.2 mol) were subsequently added and the mixture was heated to reflux under argon for 6 h. The mixture was subsequently evaporated to

remove DMF and quenched with EtOAc (1.5 L) and H₂O (1 L). The mixture was stirred for 10 min and extracted with EtOAc (3 × 0.5 L), the combined organic layers were washed with brine (3 × 0.5 L), dried over Na₂SO₄ and concentrated in vacuo. Obtained oily residue **3** (210 g, 93% purity) was used in the next step without purification.

C. To a cold (0°C) stirred solution of **3** (210 g, 93% purity, 0.74 mol), under nitrogen, in a 2:1 mixture of acetonitrile/water (1.68 L) was added solid N-bromosuccinimide (193 g, 1.08 mole) in three portions over a period of 15 min. The resultant orange mixture was stirred at 0°C for an additional period of 1 h and then allowed to warm to room temperature. After 4 h, the reaction mixture was treated with 10% aqueous sodium thiosulfate, diluted with ethyl acetate (1.5 L) and washed with water (4 × 300 mL) and brine (4 × 300 mL). Evaporation of the organic solvents results in the compound **4** (122 g, 0.43 mol) which was used in the next step without purification.

D. Compound **4** (122 g, 0.43 mol) and thiourea (33 g, 0.44 mol) were dissolved in EtOH (1.5 L) and stirred under reflux overnight. After the reaction was complete (confirmed by HNMR), the organic solvents were evaporated, and the crude residue was partitioned in EtOAc/H₂O (1 L:1 L). The lower layer was carefully basified with 10% aq NaOH to pH=9 and extracted with CH₂Cl₂ (3 × 150 mL). Combined organic layers was washed with brine (2 × 100 mL), dried over Na₂SO₄ and evaporated to give product **5** (80 g, 0.28 mol)

E. A solution of **5** (80 g, 0.28 mol) and N-chlorosuccinimide (56 g, 0.42 mol) in acetonitrile (1.5 L) was stirred at RT for one hour. After the completion of the reaction, acetonitrile was evaporated under reduced pressure and the residue was partitioned in water (400 mL) and ethyl acetate (400 mL). The layers were separated, and the aqueous layer was extracted with

ethyl acetate (3 × 150 mL). The combined organic layers were washed with brine, dried over sodium sulfate, filtered and concentrated to give product **6** (60 g, crude, 70% purity) which was used immediately in the next step without purification.

- 5 F. To a round bottomed flask was added crude compound **6** (60 g, crude, 70% purity), copper (II) chloride (38 g, 0.28 mol), and tert-butyl nitrite (35.6 mL, 0.3 mol) in CH₃CN (1 L). The mixture was heated to 40° C. for 2 hours, then the mixture was diluted with 1N HCl and extracted with EtOAc. The organic extract was
10 washed with water (2 × 100 mL), brine (2 × 100 mL), dried over Na₂SO₄, filtered and concentrated in vacuo to give compound **7**, ethyl 2-acetamido-3-(2,5-dichlorothiazol-4-yl) propanoate. The product was purified by CC (5.5 g, 0.018 mol)

- G. To the solution of **7** (5.5 g, 0.018 mol) in CH₃OH (30 mL) KOH
15 (1.1 g, 0.0198 mol) in water (5 mL) was added in few portions and the resulting mixture was stirred overnight. After the reaction was complete (confirmed by HNMR), the organic solvent was evaporated, and the crude residue was partitioned in MTBE/H₂O (30 mL : 50 mL). The organic layer was discarded; the
20 water layer was acidified with 10% aq. NaHSO₄ to pH = 3 and extracted with DCM (3 × 50 mL). Combined organic layer was dried over Na₂SO₄ and evaporated under reduced pressure to give compound **8** (3.2 g, 0.011 mol), which was used in the next step without purification.

- 25 H. 2-acetamido-3-(2,5-dichlorothiazol-4-yl)propanoic acid **8** (3.2 g, 0.011 mol) was dissolved in DCM (30 mL), followed by CDI (1.9 g, 0.012 mol) added in a few portions. After gas evolution stopped, 2-ethoxyethan-1-ol (5.3 mL, 0.055 mol) was added and the mixture was stirred overnight. After the reaction was
30 complete, the mixture was diluted with DCM (50 mL), washed with 1 N HCl (3×15 mL), sat aq NaHCO₃ (3×20 mL), brine (2× 10 mL), dried over Na₂SO₄ and evaporated under reduced pressure. Crude

product was purified with CC to give target compound as beige solid (1.5 g, 4.2 mmol)

Analytical data: ^1H NMR (CDCl_3), δ_{H} (ppm): 1.20 (t, 3H, CH_3), 2.01 (s, 3H, CH_3), 3.22 (d, 2H, CH_2), 3.50 (d, 2H, CH_2), 3.63 (t, 2H, CH_2), 4.28 (t, 2H, CH_2), 4.95 (d, 1H, CH), 6.40 (br.s, 1H, NH);
 5 ESI: Calculated[M] ($\text{C}_{12}\text{H}_{16}\text{O}_4\text{N}_2\text{SCl}_2$), $m/z=354$ ($\text{Cl}=35.0$), 356 ($1\text{Cl}=35.0$ and $2\text{Cl}=35.6$). Found $[\text{M}+\text{H}^+]=355.1$

Example 9: Testing post-emergency herbicidal activity of selected non-coding heterocyclic amino acids (NCHAA).

The tests were performed on Romaine lettuce (*Lactuca sativa* L.) plants at the stage 2 to 3 leaves. The plants were grown on 300
 10 well trays packed with soil, well dimensions 2 X 2 X 5 cm. The test dilution containing a test material listed in Tables 1, 2 & 3. Each compound was dissolved in 0.1% water solution of agronomically acceptable surfactant Silwet to final concentrations ranging from 0.0% (Control) to 0.5%. Two weeks
 15 after the treatment the herbicidal effects of the respective test material were visually evaluated by a comparison with the control plants. In addition, the aboveground part of the plant was neatly cut and weighed (wet weight). Each test was performed on 20 to 40 plants. Tested compounds are listed in Table 1.

20 Table 1: chemical and code names of the tested compounds

Code	Chemical Name
501	2-amino-3-(thiophen-2-yl)propanoic acid
502	2-amino-3-(thiophen-3-yl)propanoic acid
504	2-amino-3-[(thiophene-3-sulfonyl)amino]propanoic acid
506	2-amino-3-[(4-fluorothiophene-3-sulfonyl)amino]propanoic acid
507	methyl 2-amino-3-[(thiophene-3-sulfonyl)amino]propanoate
508	pentyl 2-amino-3-[(thiophene-3-sulfonyl)amino]propanoate
509	3-(5-cyano-3-thienyl)alanine

510	2-amino-3-[4-(trifluoromethyl)thiophen-2-yl]propanoic acid
511	3-amino-3-(4-bromothiophen-3-yl)propanoic acid
512	2-amino-3-(2,4,5-trimethylthiophen-3-yl)propanoic acid
513	butyl 2-amino-3-(thiophen-3-yl)propanoate
514	2-amino-3-[(2,5-dichlorothiophene-3-sulfonyl)amino]propanoic acid
515	2-amino-3-[(2,5-dichloro-4-methylthiophene-3-sulfonyl)amino]propanoic acid
516	2-amino-3-(2-chlorothiophen-3-yl)propanoic acid
517	2-amino-3-(2,5-dichlorothiophen-3-yl)propanoic acid
518	2-amino-3-(5-chlorothiophen-3-yl)propanoic acid
519	2-amino-3-(2,5-dihydro-1,3-thiazol-4-yl)propanoic acid
520	2-amino-3-(1,3-thiazol-5-yl)propanoic acid
521	2-amino-3-[(2,5-dichloro-4-(trifluoromethyl)thiophene-3-sulfonyl)amino]propanoic acid
522	2-amino-3-(2-amino-1,3-thiazol-4-yl)propanoic acid
523	methyl 2-amino-3-[(2,5-dichlorothiophene-3-sulfonyl)amino]propanoate
524	ethyl 2-amino-3-[(2,5-dichlorothiophene-3-sulfonyl)amino]propanoate
525	2-propoxyethyl 2-amino-3-[(2,5-dichlorothiophene-3-sulfonyl)amino]propanoate
526	[2-(carboxyamino)-3-ethoxy-3-oxopropyl](2,5-dichlorothiophene-3-sulfonyl)carbamic acid
527	2-amino-3-(2,5-dichloro-1,3-thiazol-4-yl)propanoic acid
528	2-amino-3-(5-chloro-1,3-thiazol-4-yl)propanoic acid
529	2-amino-3-(1,2,5-thiadiazol-3-yl)propanoic acid
532	2-amino-3-(1,2,4-thiadiazol-5-yl)propanoic acid
534	2-amino-3-(furan-3-yl)propanoic acid
542	2-amino-3-(1,3-oxazol-4-yl)propanoic acid
545	2-formamido-3-(thiophen-3-yl)propanoic acid
546	methyl 2-amino-3-(thiophen-3-yl)propanoate
547	ethyl 2-amino-3-(thiophen-3-yl)propanoate

548	[2-amino-3-(thiophen-3-yl)propanamido]acetic acid
549	2-amino-N-[2-(2-hydroxyethoxy)ethyl]-3-(thiophen-3-yl)propanamide
550	ethyl 2-butanamido-3-(dichloro-1,3-thiazol-4-yl)propanoate
551	2-butoxyethyl 2-acetamido-3-(2,5-dichloro-1,3-thiazol-4-yl)propanoate
552	2-amino-3-(2,5-dibromothiophen-3-yl)propanoic acid
553	2-amino-3-(5-nitrothiophen-3-yl)propanoic acid
554	butyl 3-(dichloro-1,3-thiazol-4-yl)-2-acetamidopropanoate
555	2-ethoxyethyl 3-(dichloro-1,3-thiazol-4-yl)-2-acetamidopropanoate
556	2-amino-3-[5-(trifluoromethyl)thiophen-3-yl]propanoic acid
557	(2S)-2-amino-3-(3,5-dioxo-1,2,4-oxadiazolidin-2-yl)propanoic acid
558	2-amino-3-[(2,5-dibromothiophene-3-sulfonyl)amino]propanoic acid
559	2-amino-3-(5-chloro-2-methylthiophen-3-yl)propanoic acid
560	2-amino-3-(2-bromothiophen-3-yl)propanoic acid
561	2-amino-3-(1,1-dioxo-1H-6-thiolan-3-yl)propanoic acid
562	2-amino-3-(thiolan-3-yl)propanoic acid
563	[2-amino-2-(thiophen-3-yl)ethyl]phosphonic acid
564	2-amino-3-(2,5-dimethyl-1,1-dioxo-1H-6-thiophen-3-yl)propanoic acid
565	3-(2,5-dioxo-2,5-dihydrothiophen-3-yl)-2-(phosphonoamino)propanoic acid
566	2-amino-3-[4-(trifluoromethyl)thiophen-3-yl]propanoic acid
567	ethyl 2-acetamido-3-(2,5-dichloro-1,3-thiazol-4-yl)propanoate
568	methyl 2-amino-3-(2,5-dichlorothiophen-3-yl)propanoate
569	ethyl 2-amino-3-(2,5-dichlorothiophen-3-yl)propanoate
570	2-(2-methoxyethoxy)ethyl 2-amino-3-(thiophen-3-yl)propanoate
571	ethyl 2-acetamido-3-(thiophen-3-yl)propanoate
573	ethyl 3-(2,5-dichlorothiophen-3-yl)-2-acetamidopropanoate
574	ethyl 3-(2,5-dichlorofuran-3-yl)-2-acetamidopropanoate

575	propyl 2-amino-3-(2,5-dichlorofuran-3-yl)propanoate
576	4-(2-acetamido-3-ethoxy-3-oxopropyl)-3-methyl-1,3-thiazol-3-ium chloride
577	2-(2-ethoxyethoxy)ethyl 3-(2,5-dichlorothiophen-3-yl)-2-acetamidopropanoate
578	pentyl 2-acetamido-3-(1,3,4-oxadiazol-2-yl)propanoate
580	ethyl 2-amino-3-[(2,5-dibromothiophene-3-sulfonyl)amino]propanoate
595	butyl 3-(5-chloro-1,2,4-thiadiazol-3-yl)-2-acetamidopropanoate
599	2-amino-3-(1H-indazol-3-yl)propanoic acid hydrochloride[HCl]
601	2-amino-3-(pyridazin-4-yl)propanoic acid
602	2-amino-3-(pyridin-4-yl)propanoic acid
603	2-amino-3-(pyridin-3-yl)propanoic acid dihydrochloride
605	3-(5-Hydroxy-3-pyridinyl)alanine
606	2-amino-3-(5-methylpyridin-3-yl)propanoic acid
607	2-amino-3-(4-aminopyridin-2-yl)propanoic acid
608	2-amino-3-(2-aminopyridin-4-yl)propanoic acid
609	2-amino-3-(6-aminopyridin-2-yl)propanoic acid
610	2-amino-3-(5-aminopyridin-3-yl)propanoic acid
612	2-amino-3-(5-sulfanylpypidin-3-yl)propanoic acid
613	2-amino-3-(2-sulfanylpypidin-4-yl)propanoic acid
614	2-amino-3-(pyrimidin-5-yl)propanoic acid
616	2-amino-3-(4-amino-6-chloropyrimidin-2-yl)propanoic acid
618	2-amino-3-(pyrimidin-2-yl)propanoic acid dihydrochloride
619	2-amino-3-(4-hydroxypyrimidin-2-yl)propanoic acid
620	2-amino-3-(2,4-dioxo-1,2,3,4-tetrahydropyrimidin-5-yl)propanoic acid
621	2-amino-3-(pyrazin-2-yl)propanoic acid
622	2-amino-3-(5-chloropyridin-3-yl)propanoic acid
624	2-amino-3-(2,5-dichloropyridin-3-yl)propanoic acid

625	2-amino-3-(pyrimidin-4-yl)propanoic acid
626	2-amino-3-(5-fluoropyridin-3-yl)propanoic acid
627	2-amino-3-(6-chloropyridin-3-yl)propanoic acid
628	2-amino-3-(2,6-dichloropyridin-4-yl)propanoic acid
629	2-amino-3-(3,5-dichloropyridin-4-yl)propanoic acid
630	2-amino-3-(3,5-difluoropyridin-4-yl)propanoic acid
631	2-amino-3-[2-(dimethylamino)pyridin-4-yl]propanoic acid
632	2-amino-3-(2-bromopyridin-4-yl)propanoic acid
633	2-amino-3-(5,6-dibromopyridin-3-yl)propanoic acid
634	2-amino-3-(2,6-dibromopyridin-4-yl)propanoic acid
635	2-amino-3-(2,3-dibromopyridin-4-yl)propanoic acid
637	2-amino-3-[5-(trifluoromethyl)pyridin-3-yl]propanoic acid
641	2-amino-3-(5,6-dichloropyridin-3-yl)propanoic acid
642	2-amino-3-(2-oxo-1,2-dihydropyridin-4-yl)propanoic acid
643	2-amino-3-[4-(dimethylamino)pyridin-3-yl]propanoic acid
644	2-amino-3-(2-oxo-1,2-dihydropyridin-3-yl)propanoic acid
645	2-amino-3-(6-oxo-1,6-dihydropyrimidin-4-yl)propanoic acid
646	2-amino-3-(6-oxo-1,6-dihydropyrimidin-5-yl)propanoic acid
650	2-amino-3-(6-oxo-1,6-dihydropyridin-3-yl)propanoic acid
652	2-amino-3-(2,6-dioxo-1,2,3,6-tetrahydropyrimidin-4-yl)propanoic acid
653	2-amino-3-(6-oxo-2-sulfanyl-1,6-dihydropyrimidin-4-yl)propanoic acid
654	propyl 2-amino-3-(2-bromopyridin-4-yl)propanoate
655	2-amino-3-(2-bromo-3,5-difluoropyridin-4-yl)propanoic acid
656	propyl 2-amino-3-(2-bromo-3,5-difluoropyridin-4-yl)propanoate
657	2-amino-3-[(2-bromopyridine-4-sulfonyl)amino]propanoic acid
658	propyl 2-amino-3-[(2-bromopyridine-4-sulfonyl)amino]propanoate

661	ethyl 2-amino-3-(5,6-dibromopyridin-3-yl)propanoate
662	ethyl 2-amino-3-(2,3-dibromopyridin-4-yl)propanoate acid
663	2-amino-3-[2-chloro-5-(trifluoromethyl)pyridin-3-yl]propanoic acid
664	2-amino-3-(2-amino-6-oxo-1,6-dihydropyrimidin-5-yl)propanoic acid
665	2-amino-3-(6-hydroxy-5-nitropyridin-3-yl)propanoic acid
666	methyl 2-amino-3-(2-bromopyridin-4-yl)propanoate
667	3-(2-amino-2-carboxyethyl)-1-methylpyridin-1-ium
668	3-(2-amino-2-carboxyethyl)-1-hydroxypyridin-1-ium
669	2-amino-3-(4-amino-6-hydroxy-2-methylpyrimidin-5-yl)propanoic acid
670	methyl 2-amino-3-(2,6-dibromopyridin-4-yl)propanoate
671	ethyl 3-(6-bromopyridin-3-yl)-2-acetamidopropanoate
672	methyl 3-(6-bromopyridin-3-yl)-2-acetamidopropanoate
673	ethyl 2-acetamido-3-(2-methoxypyrimidin-4-yl)propanoate
674	2-(2-methoxyethoxy)ethyl 2-amino-3-(6-bromopyridin-3-yl)propanoate
675	2-(2-ethoxyethoxy)ethyl 2-amino-3-(6-bromopyridin-3-yl)propanoate
676	5-(2-amino-2-carboxyethyl)-1-methylpyrimidin-1-ium
679	2-amino-3-[2-(trifluoromethyl)pyridin-4-yl]propanoic acid hydrochloride[HCl]
682	ethyl 3-[(2-bromopyridin-4-yl)oxy]-2-acetamidopropanoate
683	ethyl 2-acetamido-3-(pyridin-4-yloxy)propanoate
702	2-amino-4-(1H-pyrrol-3-yl)butanoic acid
703	2-amino-3-(1H-pyrrol-2-yl)propanoic acid
704	2-amino-3-(1H-pyrrol-3-yl)propanoic acid
709	2-amino-3-(4H-1,2,4-triazol-3-yl)propanoic acid
710	(2S)-2-hydroxy-3-(1H-imidazol-4-yl)propanoic acid
714	ethyl 2-[[[(benzyloxy)carbonyl]amino]-3-(1H-1,2,4-triazol-3-yl)propanoate
717	2-amino-3-(4-methyl-4H-1,2,4-triazol-3-yl)propanoic acid

770	2-amino-3-(1-methyl-1H-1,2,4-triazol-5-yl)propanoic acid dihydrochloride
771	2-amino-3-(1-methyl-1H-1,2,3-triazol-4-yl)propanoic acid hydrochloride
772	2-amino-3-(2-methyl-2H-1,2,3,4-tetrazol-5-yl)propanoic acid hydrochloride
773	2-amino-3-(dimethyl-4H-1,2,4-triazol-3-yl)propanoic acid hydrochloride
774	(2S)-2-amino-3-[5-(trifluoromethyl)-1H-pyrazol-4-yl]propanoic acid
775	2-(2-butoxyethoxy)ethyl 2-amino-3-(2H-1,2,3-triazol-4-yl)propanoate

The degree of growth inhibition and damage was evaluated according to the parameters in Table 2. Plant development at 7, 14, and 21 DAA (days after application) were evaluated on a scale of 0 to 100, in which score 0 represents dead plants and score 100 represents healthy plants according to plant vigor, height, and leaf color. Each test included 20 to 40 plants.

Table 2: Activity Index

Activity Index	Plant's development vs Control (% of Control)
Maximal	Less than 15
Very Strong	From 15 to 25
Strong	From 25 to 50
Moderate	From 50 to 75
Weak	More than 75

10

Results:

The observed activity is demonstrated in Table 3.

Table 3: post-emergency herbicidal activity of tested compounds

Code	Activity	Code	Activity	Code	Activity	Code	Activity
501	Strong	552	Maximal	608	Moderate	657	Weak

502	Very Strong	553	Weak	609	Weak	658	Weak
504	Weak	554	Maximal	610	Weak	661	Moderate
506	Weak	555	Maximal	612	Weak	662	Moderate
507	Weak	556	Maximal	613	Weak	663	Moderate
508	Weak	557	Weak	614	Weak	664	Weak
509	Maximal	558	Very Strong	616	Weak	665	Weak
510	Strong	559	Moderate	618	Weak	666	Maximal
511	Weak	560	Strong	619	Weak	667	Weak
512	Weak	561	Weak	620	Weak	668	Weak
513	Very Strong	562	Weak	621	Weak	669	Weak
514	Weak	563	Weak	622	Moderate	670	Very Strong
515	Weak	564	Weak	624	Moderate	671	Weak
516	Maximal	565	Weak	625	Weak	672	Moderate
517	Maximal	566	Maximal	626	Strong	673	Weak
518	Strong	567	Maximal	627	Moderate	674	Moderate
519	Moderate	568	Maximal	628	Very Strong	675	Moderate
520	Weak	569	Maximal	629	Moderate	676	Very Strong
521	Weak	570	Very Strong	630	Strong	679	Strong
522	Weak	571	Very Strong	631	Weak	682	on-going
523	Weak	573	Maximal	632	Maximal	683	on-going
524	Weak	574	Moderate	633	Strong	702	Weak
525	Weak	575	Moderate	634	Very Strong	703	Weak
526	Weak	576	Maximal	635	Weak	704	Weak
527	Maximal	577	Strong	637	Weak	709	Maximal
528	Weak	578	Strong	641	Very Strong	710	Weak
529	Moderate	579	Very Strong	642	Weak	712	Maximal
532	Moderate	580	Very Strong	643	Weak	714	Weak
534	Strong	581	Moderate	644	Weak	715	Maximal

542	Weak	594	Strong	645	Weak	716	Moderate
545	Weak	595	Strong	646	Weak	717	Weak
546	Very Strong	601	Weak	650	Weak	770	Weak
547	Very Strong	602	Moderate	652	Weak	771	Weak
548	Strong	603	Strong	653	Weak	772	Moderate
549	Weak	605	Weak	654	Strong	773	Weak
550	Maximal	606	Weak	655	Maximal	774	Very Strong
551	Maximal	607	Weak	656	Very Strong	775	Maximal

Example 10: Testing herbicidal activity of selected non-coding heterocyclic amino acids (NCHAA) on the development of weeds and crops.

The experiment included 225 pots. Weed seeds were sown in 0.3-liter pots, containing medium-heavy clay-loam soil from Newe Ya'ar Research Center organic fields (55% clay, 23% silt, 20% sand, 2% organic matter, pH 7.1). The experiment was conducted in a completely randomized design. Each treatment was replicated 5 times (5 pots). The herbicides were applied at 200 L/ha with a motorized sprayer equipped with a Tee Jet 8001E nozzle (Spraying Systems Co., North Ave., Wheaton, IL. 60188, USA) and operated at a pressure of 300 kPa. The pots were transferred to a glasshouse 24 hours after herbicide application and were sprinkler irrigated to field capacity of the soil. The plants were grown in the glasshouse during the entire experiment. Plant development at 6, 12, 19, 26 and 32 days after application (DAA) were evaluated on a scale of 0 to 100%, in which 0 represents dead plants and 100% represents healthy plants according to plant vigor, height, and leaf color.

Tested weeds & crops:

Phalaris minor (Cannarygrass); *Setaria verticillata* (Bristlegrass); *Solanum nigrum* (Black nightshade) *Sinapis*

arvensis (Mustard); *Silybum marianum* (Thistle); *Chenopodium album* (Lambsquarter); *Amaranthus* (Pigweed); Fodder corn; *Avena sativa* (Cultured oats).

Plants development at 32 days after application (DAA) is shown in Table 4. Plant development was evaluated on a scale of 0 to 100%, in which 0 represents dead plants and 100% represents healthy plants according to plant vigor, height, and leaf color.

Table 4: Effect of NCHAA on the development of selected weeds & crops

Plant	Plants' Development (% of Control group) following treatment with NCHAAs	
	Compound 632	Compound 517
WEEDS		
<i>Solanum nigrum</i> (Black nightshade)	25%	15%
<i>Sinapis arvensis</i> (Mustard)	80%	0%
<i>Marianum</i> (Thistle)	15%	35%
<i>Amaranthus blitoides</i> (Pigweed)	100%	10%
<i>Chenopodium album</i> (Lambsquarter)	20%	10%
<i>Phalaris minor</i> (Cannarygrass)	10%	60%
<i>Setaria verticillata</i> (Bristlegrass)	20%	100%
CROPS		
<i>Avena sativa</i> (Cultured oats)	100%	100%
Fodder Corn	100%	90%

Example 11: Testing herbicidal activity of selected non-coding heterocyclic amino acids (NCHAA) on seeds germination & early plants development.

Seeds:

Seeds of Lettuce R. (Super-Jericho, non-sterilized) were obtained from Ben Shahar Moshe Ltd., 99% purity. NCHAA were selected from compounds listed in the Table 1.

Filter Paper Bioassays with Lettuce seeds:

The protocol is following Bertin et al. 2009 and Movellan et al. 2014 with specified modifications as described below.

Seeds were placed on Whatman no. 1 filter paper (Whatman, Middlesex, U.K.) in Petri dishes (10 seeds per plate) supplemented with 2.0ml of water (Control) or with a solution comprising 1mM, 0.1mM, 0.01mM and 0.001mM of test material. Petri dishes with seeds were placed in a tray at an angle of 45°. The trays were kept in dark for 48 hours and then transferred to the growth chamber (22°C, 0.045 mmol X m⁻² X s⁻¹ photosynthetic photon flux density; 6/18 dark/ light cycle) for additional 4 days. Each experiment was performed at least in two repeats. The development of radicle and shoots of experimental and control plants were visually assessed 6 days after the beginning of the test to determine Minimal Effective Concentration (MEC) of test material. In the context of the invention, MEC is defined as the lowest concentration level of a test material that caused deviation (absence of germination or malformation of radicle and shoots) from the plant's development in the Control group. MEC is expressed in an arbitrary unit as activity score, as presented in Table 5:

Table 5: MEC as activity score

MEC	Activity score
More than 1 mM	Weak
1 mM	Moderate
0.1 mM	Strong
0.01 mM and less	Maximal

Table 6: herbicidal activity of selected non-coding heterocyclic amino acids (NCHAA) on seeds germination & early plants development

Code	Activity	Code	Activity	Code	Activity	Code	Activity
501	Maximal	553	Weak	610	Weak	653	Weak
502	Maximal	555	Strong	612	Weak	654	Strong
504	Weak	556	Strong	613	Weak	655	Strong
506	Weak	557	Weak	614	Weak	656	Strong
507	Weak	558	Maximal	616	Weak	657	Weak
508	Weak	561	Weak	618	Weak	658	Weak
509	Strong	562	Weak	619	Weak	661	Maximal
511	Weak	563	Weak	620	Weak	662	Strong
512	Weak	564	Weak	621	Weak	663	Strong
513	Strong	565	Strong	622	Strong	664	Moderate
514	Weak	566	Strong	624	Moderate	665	Moderate
515	Weak	567	Weak	625	Moderate	666	Strong
516	Maximal	569	Strong	626	Strong	667	Weak
517	Maximal	570	Maximal	627	Strong	668	Weak
519	Maximal	571	Strong	628	Moderate	669	Weak
520	Strong	573	Strong	629	Weak	670	Strong
521	Weak	574	Strong	630	Moderate	671	Strong
522	Weak	575	Strong	631	Weak	672	Strong

523	Weak	576	Moderate	632	Strong	673	Weak
524	Weak	577	Moderate	633	Strong	674	Strong
525	Weak	579	Strong	634	Strong	675	Strong
526	Weak	580	Strong	635	Weak	676	Moderate
527	Moderate	581	Moderate	637	Strong	679	Strong
528	Moderate	595	Strong	639	Strong	702	Weak
529	Strong	599	Maximal	640	Weak	703	Weak
532	Strong	601	Weak	641	Strong	704	Weak
534	Moderate	602	Strong	642	Weak	709	Moderate
542	Weak	603	Strong	643	Weak	710	Weak
545	Weak	605	Weak	644	Weak	712	Moderate
546	Maximal	606	Weak	645	Weak	714	Moderate
547	Maximal	607	Weak	646	Weak	715	Moderate
549	Weak	608	Moderate	650	Moderate	716	Moderate
552	Moderate	609	Weak	652	Weak		

Discussion:

Design of non-coding heterocyclic amino acids (NCHAA) was intended to mimic natural aromatic amino acids, such as phenylalanine, tyrosine, histidine and tryptophan. These compounds were tested in a range of experimental setups, such as on seeds placed on the filter paper as well as in experiments with pre- or post-emergency treatment of weeds and crops. The experimental data suggest that, despite diversity of chemical structures, NCHAA as a group possesses a significant herbicidal activity. Surprisingly, selected NCHAAAs demonstrated herbicidal activity significantly surpassing natural (such as m-Tyrosine) and synthetic non-coded amino acids with "non-heterocyclic, all carbon" aromatic rings, such as m-tyrosine compounds described by US patent US8,461,085 (Leslie A. Weston et. al, Cornell Business & Technology Park). NCHAA appeared as a new family of

compounds useful for crop protection, in particularly in crop protection used to destroy unwanted vegetations.

Unless otherwise defined, all technical and/or scientific terms used herein have the same meaning as commonly understood by one
5 of ordinary skill in the art to which the invention pertains. Although methods and materials similar or equivalent to those described herein can be used in the practice or testing of embodiments of the invention, exemplary methods and/or materials are described below. In case of conflict, the patent
10 specification, including definitions, will prevail. In addition, the materials, methods, and examples are illustrative only and are not intended to be necessarily limiting.

As used herein the terms "comprises", "comprising", "includes", "including", "having" and their conjugates mean "including but
15 not limited to".

The term "consisting of" means "including and limited to".

As used herein, the singular form "a", "an" and "the" include plural references unless the context clearly dictates otherwise. For example, the term "a compound" or "at least one compound"
20 may include a plurality of compounds, including mixtures thereof.

It will be understood that when an element is referred to as being "on," "attached" to, "connected" to, "coupled" with, "contacting," etc., another element, it can be directly on,
25 attached to, connected to, coupled with and/or contacting the other element or intervening elements can also be present. In contrast, when an element is referred to as being, for example, "directly on," "directly attached" to, "directly connected" to, "directly coupled" with or "directly contacting" another
30 element, there are no intervening elements present. It will also be appreciated by those of skill in the art that references to a structure or feature that is disposed "adjacent" another

feature can have portions that overlap or underlie the adjacent feature.

It will be understood that, although the terms first, second, etc., may be used herein to describe various elements, components, regions, layers and/or sections, these elements, components, regions, layers and/or sections should not be limited by these terms. Rather, these terms are only used to distinguish one element, component, region, layer and/or section, from another element, component, region, layer and/or section.

As will be appreciated by those of skill in the art, the compounds of the various formulas disclosed herein may contain chiral centers, e.g., asymmetric carbon atoms. Thus, the present disclosure is concerned with the synthesis of both: (i) racemic mixtures of the active compounds, and (ii) enantiomeric forms of the active compounds. The resolution of racemates into enantiomeric forms and racemization of optically active enantiomeric form can be done in accordance with known procedures in the art. Geometric isomers of double bonds and the like may also be present in the compounds disclosed herein, and all such stable isomers are included within the present disclosure unless otherwise specified. Also included in the compounds of the disclosure are tautomers (e.g., tautomers of triazole and/or imidazole) and rotamers. All chains defined by the formulas herein which include three or more carbons may be saturated or unsaturated unless otherwise indicated.

It is understood that substituents and substitution patterns on the compounds used in the method of the present invention can be selected by one of ordinary skill in the art to provide compounds that are chemically stable and that can be readily synthesized by techniques known in the art from readily available starting materials. If a substituent is itself substituted with more than one group, it is understood that

these multiple groups may be on the same carbon or on different carbons, so long as a stable structure results.

An "optionally substituted" group refers to a functional group in which one or more bonds to a hydrogen atom contained therein
5 are replaced by a bond to non-hydrogen or non-carbon atoms, provided that normal valencies are maintained and that the substitution results in a stable compound. Substituted groups also include groups in which one or more bonds to a carbon(s) or hydrogen(s) atom are replaced by one or more bonds, including
10 double or triple bonds, to a heteroatom. Where multiple substituent moieties are disclosed or claimed, the substituted compound can be independently substituted by one or more of the disclosed or claimed substituent moieties, singly or plurality. By independently substituted, it is meant that the (two or more)
15 substituents can be the same or different. In choosing the compounds of the present invention, one of ordinary skill in the art will recognize that the various substituents are to be chosen in conformity with well-known principles of chemical structure connectivity.

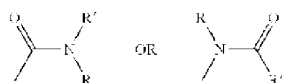
20 As used herein, "H" refers to a hydrogen atom. "C" refers to a carbon atom. "N" refers to a nitrogen atom. "O" refers to an oxygen atom. "Halo" refers to F, Cl, Br or I. The term "hydroxy," as used herein, refers to an -OH moiety. "Br" refers to a bromine atom. "Cl" refers to a chlorine atom. "I" refers to an iodine
25 atom. "F" refers to a fluorine atom. An "acyl group" is intended to mean a group -C(O)-R, where R is a suitable substituent, for example, an acetyl group, a propionyl group, a butyryl group, a benzoyl group, or an alkylbenzoyl group. "Alkyl," as used herein, refers to a straight or branched chain hydrocarbon
30 containing from 1 or 2 to 10 or 20 or more carbon atoms (e.g., C2, C3, C4, C5, C6, C7, C8, C9, C10, C11, C12, C13, C14, C15, etc.). In some embodiments the alkyl can be a lower alkyl. "Lower alkyl" refers to straight or branched chain alkyl having from 1

to 3, or from 1 to 5, or from 1 to 8 carbon atoms. Representative examples of alkyl include, but are not limited to, methyl, ethyl, n-propyl, iso-propyl, n-butyl, sec-butyl, iso-butyl, tert-butyl, n-pentyl, isopentyl, neopentyl, n-hexyl, 3-methylhexyl, 2,2-dimethylpentyl, 2,3-dimethylpentyl, n-heptyl, n-octyl, n-nonyl, n-decyl, and the like. As used herein, the identification of a carbon number range, e.g., C1-C12 alkyl, is intended to include each of the component carbon number moieties within such range, so that each intervening carbon number and any other stated or intervening carbon number value in that stated range is encompassed, such that sub-ranges of carbon number within specified carbon number ranges may independently be specified. For example, C1-C12 alkyl is intended to include methyl, ethyl, propyl, butyl, pentyl, hexyl, heptyl, octyl, nonyl, decyl, undecyl and dodecyl, including straight chain as well as branched groups, as noted above, and the carbon number range C1-C12 alkyl may also be more restrictively specified as sub-ranges such as C1-C4 alkyl, C2-C8 alkyl, C2-C4 alkyl, C3-C5 alkyl, or any other sub-range within the broader carbon number range. In addition, ranges of carbon numbers specifically excluding a carbon number or numbers are contemplated, as are sub-ranges excluding either or both of carbon number limits of specified ranges. As generally understood by those of ordinary skill in the art, "saturation" refers to the state in which all available valence bonds of an atom (e.g., carbon) are attached to other atoms. Similarly, "unsaturation" refers to the state in which not all the available valence bonds are attached to other atoms; in such compounds the extra bonds usually take the form of double or triple bonds (usually with carbon). For example, a carbon chain is "saturated" when there are no double or triple bonds present along the chain or directly connected to the chain (e.g., a carbonyl), and is "unsaturated" when at least one double or triple bond is present along the chain or directly connected to the chain (e.g., a carbonyl). Further, the presence or absence

of a substituent depending upon chain saturation will be understood by those of ordinary skill in the art to depend upon the valence requirement of the atom or atoms to which the substituent binds (e.g., carbon). "Alkenyl," as used herein, refers to a straight or branched chain hydrocarbon containing from 1 or 2 to 10 or 20 or more carbons, and containing at least one carbon-carbon double bond, formed structurally, for example, by the replacement of two hydrogens. Representative examples of "alkenyl" include, but are not limited to, ethenyl, 2-propenyl, 2-methyl-2-propenyl, 3-butenyl, 4-pentenyl, 5-hexenyl, 2-heptenyl, 2-methyl-1-heptenyl, 3-decenyl and the like. "Alkynyl," as used herein, refers to a straight or branched chain hydrocarbon group containing from 1 or 2 to 10 or 20 or more carbon atoms, and containing at least one carbon-carbon triple bond. Representative examples of alkynyl include, but are not limited, to acetylenyl, 1-propynyl, 2-propynyl, 3-butyne, 2-pentyne, 1-butyne and the like. The term "cycloalkyl," as used herein, refers to a saturated cyclic hydrocarbon group containing from 3 to 8 carbons or more.

As understood in the art, the term "optionally substituted" indicates that the specified group is either unsubstituted or substituted by one or more suitable substituents. A "substituent" that is "substituted" is an atom or group which takes the place of a hydrogen atom on the parent chain or cycle of an organic molecule. "Heterocycle," as used herein, refers to a monocyclic, bicyclic or tricyclic ring system. Monocyclic heterocycle ring systems are exemplified by any 5 to 9-membered ring containing 1, 2, 3, or 4 heteroatoms independently selected from the group consisting of: O, N, and S. "Aryl" as used herein refers to a ring system having one or more aromatic rings. Representative examples of aryl include azulenyl, indanyl, indenyl, naphthyl, phenyl, tetrahydronaphthyl, and the like. "Heteroaryl" means a cyclic, aromatic hydrocarbon in which one or more carbon atoms have been replaced with heteroatoms (e.g.,

N, O or S). If the heteroaryl group contains more than one heteroatom, the heteroatoms may be the same or different. "Alkoxy," as used herein, refers to an alkyl group, as defined herein, appended to the parent molecular moiety through an oxy group, as defined herein. An "amine" or "amino" is intended to mean the group -NH_2 . "Primary amines" have one of three hydrogen atoms replaced by an alkyl or aromatic group. "Secondary amines" have two organic substituents bound to the nitrogen together with one hydrogen. "Tertiary amines" have three organic substituents bound to the nitrogen. An "amide" as used herein, refers to a functional group having a carbonyl group (C=O) linked to a nitrogen atom (N), or an organic compound that contains this group, generally depicted as:



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wherein, R and R' can independently be any covalently linked atom or atoms. The term "oxo," as used herein, refers to a =O moiety. The term "oxy," as used herein, refers to a -O- moiety. "Nitro" refers to the organic compound functional group -NO_2 . "Carbonyl" is a functional group having a carbon atom double-bonded to an oxygen atom (-C=O). "Carboxy" as used herein refers to a -COOH functional group, also written as $\text{-CO}_2\text{H}$ or -(C=O)-OH .

It will be understood that the compounds, compositions and methods provided herein may be further specified in some embodiments by provisos or limitations excluding specific substituents, groups, moieties, structures, ingredients, steps, or conditions, as applicable, in relation to various broader specifications and exemplifications set forth herein.

"Agriculturally acceptable carriers" of the invention include, without limitation, adjuvants, mixers, enhancers, etc. beneficial for application of the chemical formula. Suitable

carriers should not be phytotoxic to valuable crops, particularly at the concentrations employed in applying the compositions for selective weed control in the presence of crops and should not react chemically with the compounds of the chemical formula herein or other composition ingredients. Such mixtures can be designed for application directly to weeds or their locus or can be concentrates or formulations which are normally diluted with additional carriers and adjuvants before application. They may include inert or active components and can be solids, such as, for example, dusts, granules, water dispersible granules, or wettable powders, or liquids, such as, for example, emulsifiable concentrates, solutions, emulsions or suspensions. Suitable agricultural carriers useful in preparing agricultural compositions of the present invention are well known to those skilled in the art. For example, liquid carriers that can be employed include water, toluene, xylene, petroleum naphtha, crop oil, acetone, methyl ethyl ketone, cyclohexanone, trichloroethylene, perchloroethylene, ethyl acetate, amyl acetate, butyl acetate, propylene glycol monomethyl ether and diethylene glycol monomethyl ether, methanol, ethanol, isopropanol, amyl alcohol, ethylene glycol, propylene glycol, glycerine, and the like. Water is generally the carrier of choice for the dilution of concentrates. Suitable solid carriers include talc, pyrophyllite clay, silica, attapulgus clay, kieselguhr, chalk, diatomaceous earth, lime, calcium carbonate, bentonite clay, Fuller's earth, cotton seed hulls, wheat flour, soybean flour, pumice, wood flour, walnut shell flour, lignin, and the like.

It is frequently desirable to incorporate one or more surface-active agents into the compositions of the present invention. Such surface-active agents are advantageously employed in both solid and liquid compositions, especially those designed to be diluted with carrier before application. The surface-active agents can be anionic, cationic or nonionic in character and can

be employed as emulsifying agents, wetting agents, suspending agents, or for other purposes. Typical surface active agents include salts of alkyl sulfates, such as diethanolammonium lauryl sulfate; alkylarylsulfonate salts, such as calcium
5 dodecylbenzenesulfonate; alkylphenol-alkylene oxide addition products, such as nonylphenol-C.sub.18 ethoxylate; alcohol-alkylene oxide addition products, such as tridecyl alcohol-C.sub.16 ethorylate; soaps, such as sodium stearate; alkyl-naphthalenesulfonate salts, such as sodium
10 dibutyl-naphthalenesulfonate; dialkyl esters of sulfosuccinate salts, such as sodium di(2-ethylhexyl) sulfosuccinate; sorbitol esters, such as sorbitol oleate; quaternary amines, such as lauryl trimethylammonium chloride; polyethylene glycol esters of fatty acids, such as polyethylene glycol stearate; block
15 copolymers of ethylene oxide and propylene oxide; and salts of mono and dialkyl phosphate esters.

Other adjuvants commonly utilized in agricultural compositions include antifoam agents, compatibilizing agents, sequestering agents, neutralizing agents and buffers, corrosion inhibitors,
20 dyes, odorants, penetrations aids, spreading agents, sticking agents, dispersing agents, thickening agents, freeze point depressants, antimicrobial agents, and the like. The compositions can also contain other compatible components, for example, other herbicides, plant growth regulants, fungicides,
25 insecticides, and the like and can be formulated with liquid fertilizers or solid, particulate fertilizer carriers such as ammonium nitrate, urea and the like.

"Agriculturally acceptable salt" is intended to mean a salt that retains the biological effectiveness of the free acids and
30 bases of a specified compound and that is not biologically or otherwise undesirable. Examples of agriculturally acceptable salts include sulfates, pyrosulfates, bisulfates, sulfites, bisulfites, phosphates, monohydrogenphosphates,

dihydrogenphosphates, metaphosphates, pyrophosphates, chlorides, bromides, iodides, acetates, propionates, decanoates, caprylates, acrylates, formates, isobutyrate, caproates, heptanoates, propiolates, oxalates, malonates, succinates, suberates, sebacates, fumarates, maleates, butyne-1,4-dioates, hexyne-1,6-dioates, benzoates, chlorobenzoates, methylbenzoates, dinitrobenzoates, hydroxybenzoates, methoxybenzoates, phthalates, sulfonates, xylenesulfonates, phenylacetates, phenylpropionates, phenylbutyrates, citrates, lactates, γ -hydroxybutyrates, glycollates, tartrates, methane-sulfonates, propanesulfonates, naphthalene-1-sulfonates, naphthalene-2-sulfonates, and mandelates.

Throughout this application, various embodiments of this invention may be presented in a range format. It should be understood that the description in range format is merely for convenience and brevity and should not be construed as an inflexible limitation on the scope of the invention. Accordingly, the description of a range should be considered to have specifically disclosed all the possible subranges as well as individual numerical values within that range. For example, description of a range such as from 1 to 6 should be considered to have specifically disclosed subranges such as from 1 to 3, from 1 to 4, from 1 to 5, from 2 to 4, from 2 to 6, from 3 to 6 etc., as well as individual numbers within that range, for example, 1, 2, 3, 4, 5, and 6. This applies regardless of the breadth of the range.

Whenever a numerical range is indicated herein, it is meant to include any cited numeral (fractional or integral) within the indicated range. The phrases "ranging/ranges between" a first indicate number and a second indicate number and "ranging/ranges from" a first indicate number "to" a second indicate number are used herein interchangeably and are meant to include the first

and second indicated numbers and all the fractional and integral numerals therebetween.

Certain features of the invention, which are, for clarity, described in the context of separate embodiments, may also be provided in combination in a single embodiment. Conversely, various features of the invention, which are, for brevity, described in the context of a single embodiment, may also be provided separately or in any suitable sub-combination or as suitable in any other described embodiment of the invention.

10 Certain features described in the context of various embodiments are not to be considered essential features of those embodiments, unless the embodiment is inoperative without those elements.

As used herein the term "method" refers to manners, means, techniques and procedures for accomplishing a given task including, but not limited to, those manners, means, techniques and procedures either known to, or readily developed from known manners, means, techniques and procedures by practitioners of the chemical, agricultural, biological, and biochemical arts.

20 As used herein the term "plant growth regulator" refers but not limited to a compound, either natural or synthetic, that modifies or controls one or more specific physiological processes within a plant.

As used herein the term "plant" refers but not limited to whole plants, ancestors and progeny of the plants and plant parts, including seeds, shoots, stems, roots (including tubers), and plant cells, tissues and organs. The plant may be in any form including suspension cultures, embryos, meristematic regions, callus tissue, leaves, gametophytes, sporophytes, pollen, and microspores.

As used herein the term "crop protection agent" refers but not limited to an agent which is a pesticide (or a mixture of more than one pesticide) or a plant growth regulator.

As used herein the term "pesticide" refers to, but not limited to a chemical or biological agent that deters, incapacitates, kills, or otherwise discourages pests.

Compounds of this invention will generally be used as a herbicidal active ingredient in a composition. As used herein the term "composition" refers but not limited to a formulation, with at least one additional component selected from the group consisting of surfactants, solid diluents and liquid diluents, which serves as a carrier. The formulation or composition ingredients are selected to be consistent with the physical properties of the active ingredient, mode of application and environmental factors such as oil type, moisture and temperature. Useful compositions may include both liquid and solid formulation. Liquid formulations may include solutions (including emulsifiable concentrates), suspensions, emulsions (including microemulsions, oil-in-water emulsions, flowable concentrates and/or suspoemulsions) and alike, which optionally can be thickened into gels. The general types of aqueous liquid compositions are soluble concentrate, suspension concentrate, capsule suspension, concentrated emulsion, microemulsion, oil-in-water emulsion, flowable concentrate and suspo-emulsion. The general types of nonaqueous liquid compositions are emulsifiable concentrate, microemulsifiable concentrate, dispersible concentrate and oil dispersion.

The general types of solid formulations are dusts, powders, granules, pellets, prills, astilles, tablets, filled films (including seed coatings) and the like, which can be water-dispersible ("wetttable") or water-soluble. Films and coatings formed from film-forming solutions or flowable suspensions are particularly useful for seed treatment. Active ingredient can be (micro)encapsulated and further formed into a suspension or solid formulation; alternatively, the entire formulation of active ingredient can be encapsulated (or "overcoated").

Encapsulation can control or delay release of the active ingredient. Sprayable formulations are typically extended in a suitable medium before spraying. Such liquid and solid formulations are formulated to be readily diluted in the spray medium, usually water, but occasionally another suitable medium like an aromatic or paraffinic hydrocarbon or vegetable oil. Spray volumes can range from about one to several thousand liters per hectare, but more typically are in the range from about ten to several hundred liters per hectare. Sprayable formulations can be tank mixed with water or another suitable medium for foliar treatment by aerial or ground application, or for application to the growing medium of the plant. Liquid and dry formulations can be metered directly into drip irrigation systems or metered into the furrow during planting.

The formulations will typically contain effective amounts of active ingredient, diluent and surfactant within the following approximate ranges which add up to 100 percent by weight.

The compounds of the invention have (both preemergent and postemergent) herbicidal activity. As used herein the term "controlling undesired plant growth" refers to killing or injuring the vegetation or reducing its growth.

The compounds and compositions of the invention can be usefully applied by a variety of methods involving contacting a herbicidally effective amount of a compound of the invention, or a composition comprising said compound and at least one of a surfactant, a solid diluent or a liquid diluent, to the foliage or other part of the undesired plant or to the environment of the undesired plant growth such as the soil or water in which the undesired plant is growing or which surrounds the seed or other propagule of the undesired plant.

A herbicidally effective amount of the compounds of this invention is determined by a number of factors: formulation selected, method of application, amount and type of undesired

plant growth present, growing conditions, etc. In general, a herbicidally effective amount of compounds of this invention is about 0.001 to 20 kg/ha with a preferred range of about 0.004 to 1 kg/ha. One skilled in the art can easily determine the
5 herbicidally effective amount necessary for the desired level of weed control.

The compounds of the invention are applied, typically in a form of formulated composition, to a locus comprising desired vegetation (e.g., crops) and undesired plant growth (i.e.
10 weeds), both of which may be seeds, seedlings and/or larger plants, in contact with a growth medium (e.g., soil). In this locus, a composition comprising the compounds of the invention can be directly applied to a plant or any part of a plant thereof, particularly of the undesired plant growth, and/or to
15 the growth medium in contact with the plant.

Compounds of this invention can also be mixed with one or more other biologically active compounds or agents including herbicides, herbicide safeners, fungicides, insecticides, nematocides, bactericides, acaricides, plant growth regulators
20 such as insect molting inhibitors and rooting stimulants, chemosterilants, semiochemicals, repellents, attractants, pheromones, feeding stimulants, plant nutrients, other biologically active compounds or bacteria, virus or fungi to form a multi-component pesticide giving broader spectrum of
25 agricultural protection. Mixtures of the compounds of the invention with other herbicides can broaden the spectrum of activity against additional weed species and suppress the proliferation of any resistant biotypes.

Throughout this application various publications, published
30 patent applications and published patents are referenced. The disclosures of these publications in their entireties are hereby incorporated by reference into this application in order to more

fully describe the state of the art to which this invention pertains.

Certain features of the invention, which are, for clarity, described in the context of separate embodiments, may also be
5 provided in combination in a single embodiment. Conversely, various features of the invention, which are, for brevity, described in the context of a single embodiment, may also be provided separately or in any suitable subcombination or as suitable in any other described embodiment of the invention.
10 Certain features described in the context of various embodiments are not to be considered essential features of those embodiments, unless the embodiment is inoperative without those elements.

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