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Additional inventors are being named on the <u>1</u> separately numbered sheets attached hereto.		
TITLE OF THE INVENTION (500 characters max):		
HERBICIDE-TOLERANT PLANTS		
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PTO/SB/16 (12-08)

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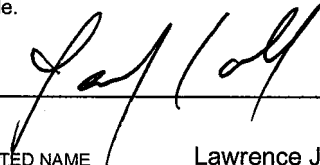
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SIGNATURE  Date September 1, 2009

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TELEPHONE (202) 467-6900 Docket Number: B248 1010.P1

**SUPPLEMENTAL SHEET TO
PROVISIONAL APPLICATION COVER SHEET (PTO/SB/16)
(Page 1 of 1)**

First Named Inventor	Scots L. Mankin	Docket Number	B248 1010.P1
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HERBICIDE-TOLERANT PLANTS

BACKGROUND OF THE INVENTION

- [0001] Rice is one of the most important food crops in the world, particularly in Asia. Rice is a cereal grain produced by plants in the genus *Oryza*. The two most frequently cultivated species are *Oryza sativa* and *Oryza glaberrima*, with *O. sativa* being the most frequently cultivated domestic rice. In addition to the two domestic species, the genus *Oryza* contains more than 20 wild species. One of these wild species, *Oryza rufipogon* (“red rice” also referred to as *Oryza sativa* subsp. *rufipogon*) presents a major problem in commercial cultivation. Red rice produces red coated seeds. After harvest, rice seeds are milled to remove their hull. After milling, domestic rice is white while wild red rice appears discolored. The presence of discolored seeds reduces the value of the rice crop. Since red rice belongs to the same species as cultivated rice (*Oryza sativa*), their genetic makeup is very similar. This genetic similarity has made herbicidal control of red rice difficult.
- [0002] Domestic rice tolerant to imidazolinone herbicides have been developed and are currently marketed under the tradename CLEARFIELD[®]. Imidazolinone herbicides inhibit a plant's acetohydroxyacid synthase (AHAS) enzyme. When cultivating CLEARFIELD[®] rice, it is possible to control red rice and other weeds by application of imidazolinone herbicides. Unfortunately, imidazolinone herbicide-tolerant red rice and weeds have developed.
- [0003] Acetyl-Coenzyme A carboxylase (acetyl-Coenzyme A carboxylase; EC 6.4.1.2) enzymes synthesize malonyl-CoA as the start of the de novo fatty acid synthesis pathway in plant chloroplasts. ACCase in grass chloroplasts is a multifunctional, nuclear-genome-encoded, very large, single polypeptide, transported into the plastid via an N-terminal transit peptide. The active form in grass chloroplasts is a homomeric protein, likely a homodimer.
- [0004] ACCase enzymes in grasses are inhibited by three classes of herbicidal active ingredients. The two most prevalent classes are aryloxyphenoxypropanoates (“FOPs”) and cyclohexanediones (“DIMs”). In addition to these two classes, a third class phenylpyrazolines (“DENS”) has been described.

[0005] A number of ACCase-inhibitor-tolerance (AIT) mutations have been found in monocot weed species exhibiting tolerance toward one or more DIM or FOP herbicides. Further, an AIT maize has been marketed by BASF. All such mutations are found in the carboxyltransferase domain of the ACCase enzyme, and these appear to be located in a substrate binding pocket, altering access to the catalytic site.

[0006] DIMs and FOPs are important herbicides and it would be advantageous if rice could be provided that exhibits tolerance to these classes of herbicide. Currently, these classes of herbicide are of limited value in rice agriculture. In some cases, herbicide-tolerance-inducing mutations create a severe fitness penalty in the tolerant plant. Therefore, there remains a need in the art for an AIT rice that also exhibits no fitness penalty. This need and others are met by the present invention.

BRIEF SUMMARY OF THE INVENTION

[0007] The present invention relates to herbicide-tolerant plants and methods of producing and treating herbicide-tolerant plants. In one embodiment, the present invention provides a rice plant tolerant to at least one herbicide that inhibits acetyl-Coenzyme A carboxylase activity at levels of herbicide that would normally inhibit the growth of a rice plant. Typically, an herbicide-tolerant rice plant of the invention expresses an acetyl-Coenzyme A carboxylase (ACCase) in which the amino acid sequence differs from an amino acid sequence of an acetyl-Coenzyme A carboxylase of a wild-type rice plant. By convention, mutations within monocot ACCase amino acid residues are typically referred to in reference to their position in the *Alopecurus myosuroides* (blackgrass) ACCase sequence (Genbank CAC84161.1) and denoted with an (*Am*). Examples of amino acid positions at which an acetyl-Coenzyme A carboxylase of a herbicide-tolerant plant of the invention differs from the acetyl-Coenzyme A carboxylase of the corresponding wild-type plant include, but are not limited to, one or more of the following positions: 1,781(*Am*), 1,999(*Am*), 2,027(*Am*), 2,041(*Am*), 2,078(*Am*), 2088(*Am*) or 2,096(*Am*). Examples of differences at these amino acid positions include, but are not limited to, one or more of the following: the amino acid at position 1,781(*Am*) is other than isoleucine; the amino acid at position 1,999(*Am*) is other than tryptophan; the amino acid at position 2,027(*Am*) is other than tryptophan; the amino acid at position 2,041(*Am*) is other than isoleucine; the amino acid at

position 2,078(*Am*) is other than aspartate; the amino acid at position 2088(*Am*) is other than cysteine; or the amino acid at position 2,096(*Am*) is other than glycine. In some embodiments, the present invention provides a rice plant expressing an acetyl-Coenzyme A carboxylase enzyme comprising an amino acid sequence that comprises one or more of the following: the amino acid at position 1,781(*Am*) is leucine or alanine; the amino acid at position 1,999(*Am*) is cysteine; the amino acid at position 2,027(*Am*) is cysteine; the amino acid at position 2,041(*Am*) is asparagine; the amino acid at position 2,078(*Am*) is glycine; the amino acid at position 2088(*Am*) is arginine or the amino acid at position 2,096(*Am*) is alanine.

[0008] The present invention also provides methods of producing herbicide-tolerant plants and plants produced by such methods. An example of a plant produced by the methods of the invention is an herbicide-tolerant rice plant which is tolerant to at least one herbicide that inhibits acetyl-Coenzyme A carboxylase activity at levels of herbicide that would normally inhibit the growth of said plant, wherein the herbicide-tolerant plant is produced by: a) obtaining cells from a plant that is not tolerant to the herbicide; b) contacting the cells with a medium comprising one or more acetyl-Coenzyme A carboxylase inhibitors; and c) generating an herbicide-tolerant plant from the cells. Herbicide-tolerant plants produced by methods of the invention include, but are not limited to, herbicide-tolerant plants generated by performing a), b) and c) above and progeny of a plant generated by performing a), b), and c) above. In one embodiment, cells used to practice methods of this type will be in the form of a callus.

[0009] The present invention provides plants expressing acetyl-Coenzyme A carboxylase enzymes comprising defined amino acid sequences. For example, the present invention provides a rice plant, wherein one or more of the genomes of said rice plant encode a protein comprising a modified version of one or both of SEQ ID NOs: 2 and 3, wherein the sequence is modified such that the encoded protein comprises one or more of the following: the amino acid at position 1,781(*Am*) is leucine or alanine; the amino acid at position 1,999(*Am*) is cysteine; the amino acid at position 2,027(*Am*) is cysteine; the amino acid at position 2,041(*Am*) is asparagine; the amino acid at position 2,078(*Am*) is glycine; the amino acid at position 2088(*Am*) is arginine or the amino acid at position 2,096(*Am*) is alanine. Table 3

below provides an alignment of the *Alopecurus myosuroides* acetyl-Coenzyme A carboxylase sequence (SEQ ID NO:1), the *Oryza sativa* Indica1 acetyl-Coenzyme A carboxylase sequence (SEQ ID NO:2) and the *Oryza sativa* Japonica acetyl-Coenzyme A carboxylase sequence (SEQ ID NO:3) with examples of positions where the wild type sequences may differ with sequences of the invention indicated.

[0010] In another embodiment, the present invention comprises seeds deposited in an acceptable depository in accordance with the Budapest Treaty, cells derived from such seeds, plants grown from such seeds and cells derived from such plants, progeny of plants grown from such seed and cells derived from such progeny. The growth of plants produced from deposited seed and progeny of such plants will typically be tolerant to acetyl-Coenzyme A carboxylase-inhibiting herbicides at levels of herbicide that would normally inhibit the growth of a corresponding wild-type plant. In one embodiment, the present invention provides a rice plant grown from a seed having ATCC accession number PTA-10267. The present invention also encompasses mutants, recombinants, and/or genetically engineered derivatives of the plant grown from a seed having ATCC accession number PTA-10267 as well as any progeny of the plant grown from a seed having ATCC accession number PTA-10267 so long as such plants or progeny have the herbicide tolerance characteristics of the plant grown from a seed having ATCC accession number PTA-10267. The present invention also encompasses cells cultured from such seeds and plants and their progeny produced from the cultured cells.

[0011] An herbicide-tolerant plant of the invention may be a member of the species *O. sativa*. Herbicide-tolerant plants of the invention are typically tolerant to aryloxyphenoxypropionate herbicides, cyclohexanedione herbicides, phenylpyrazoline herbicides or combinations thereof at levels of herbicide that would normally inhibit the growth of a corresponding wild-type plant, for example, a rice plant. In some embodiments, an herbicide-tolerant plant of the invention is not a GMO-plant. The present invention also provides an herbicide-tolerant plant that is mutagenized, for example, a mutagenized rice plant. The present invention also encompasses cells derived from the plants and seeds of the herbicide-tolerant plants described above.

[0012] The present invention provides methods for controlling growth of weeds. In one embodiment, the present invention provides a method of controlling growth of weeds in vicinity to rice plants. Such methods may comprise applying to the weeds and rice plants an amount of an acetyl-Coenzyme A carboxylase-inhibiting herbicide that inhibits naturally occurring acetyl-Coenzyme A carboxylase activity, wherein said rice plants comprise altered acetyl-Coenzyme A carboxylase activity such that said rice plants are tolerant to the applied amount of herbicide. Methods of the invention may be practiced with any herbicide that interferes with acetyl-Coenzyme A carboxylase activity including, but not limited to, aryloxyphenoxypropionate herbicides, cyclohexanedione herbicides, phenylpyrazoline herbicides or combinations thereof.

[0013] The present invention provides a method for controlling growth of weeds in vicinity to rice plants. One example of such methods may comprise applying one or more herbicides to the weeds and to the rice plants at levels of herbicide that would normally inhibit the growth of a rice plant, wherein at least one herbicide inhibits acetyl-Coenzyme A carboxylase activity. Such methods may be practiced with any herbicide that inhibits acetyl-Coenzyme A carboxylase activity. Suitable examples of herbicides that may be used in the practice of methods of controlling weeds include, but are not limited to, aryloxyphenoxypropionate herbicides, cyclohexanedione herbicides, phenylpyrazoline herbicides or combinations thereof.

[0014] The present invention encompasses a method for controlling growth of weeds. One example of such methods may comprise (a) crossing an herbicide-tolerant rice plant with other rice germplasm, and harvesting the resulting hybrid rice seed; (b) planting the hybrid rice seed; and (c) applying one or more acetyl-Coenzyme A carboxylase-inhibiting herbicides to the hybrid rice and to the weeds in vicinity to the hybrid rice at levels of herbicide that would normally inhibit the growth of a rice plant. Such methods may be practiced with any herbicide that inhibits acetyl-Coenzyme A carboxylase activity. Suitable examples of herbicides that may be used in the practice of methods of controlling weeds include, but are not limited to, aryloxyphenoxypropionate herbicides, cyclohexanedione herbicides, phenylpyrazoline herbicides or combinations thereof.

[0015] In another embodiment, the present invention includes a method for selecting herbicide-tolerant rice plants. One example of such methods may comprise (a) crossing an herbicide-tolerant rice plant with other rice germplasm, and harvesting the resulting hybrid rice seed; (b) planting the hybrid rice seed; (c) applying one or more herbicides to the hybrid rice at levels of herbicide that would normally inhibit the growth of a rice plant, wherein at least one of the herbicides inhibits acetyl-Coenzyme A carboxylase; and (d) harvesting seeds from the rice plants to which herbicide has been applied. Such methods may be practiced with any herbicide that inhibits acetyl-Coenzyme A carboxylase activity. Suitable examples of herbicides that may be used in the practice of methods of controlling weeds include, but are not limited to, aryloxyphenoxypropionate herbicides, cyclohexanedione herbicides, phenylpyrazoline herbicides or combinations thereof.

[0016] The present invention also encompasses a method for growing herbicide-tolerant rice plants. One example of such a method comprises (a) planting rice seeds; (b) allowing the rice seeds to sprout; (c) applying one or more herbicides to the rice sprouts at levels of herbicide that would normally inhibit the growth of a rice plant, wherein at least one of the herbicides inhibits acetyl-Coenzyme A carboxylase. Such methods may be practiced with any herbicide that inhibits acetyl-Coenzyme A carboxylase activity. Suitable examples of herbicides that may be used in the practice of methods of controlling weeds include, but are not limited to, aryloxyphenoxypropionate herbicides, cyclohexanedione herbicides, phenylpyrazoline herbicides or combinations thereof.

[0017] In one embodiment, the present invention provides a seed of an herbicide-tolerant rice plant. Such seed may be used to grow herbicide-tolerant rice plants, wherein a plant grown from the seed is tolerant to at least one herbicide that inhibits acetyl-Coenzyme A carboxylase activity at levels of herbicide that would normally inhibit the growth of a rice plant. Examples of herbicides to which plants grown from seeds of the invention would be tolerant include but are not limited to, aryloxyphenoxypropionate herbicides, cyclohexanedione herbicides, phenylpyrazoline herbicides or combinations thereof.

[0018] In another embodiment, the present invention provides a seed of a rice plant, wherein a plant grown from the seed expresses an acetyl-Coenzyme A carboxylase (ACCase) in which the amino acid sequence differs from an amino acid sequence of an acetyl-

Coenzyme A carboxylase of a wild-type rice plant at one or more of the following positions: 1,781(*Am*), 1,999(*Am*), 2,027(*Am*), 2,041(*Am*), 2,078(*Am*), 2088(*Am*) or 2,096(*Am*).

Examples of differences at these amino acid positions include, but are not limited to, one or more of the following: the amino acid at position 1,781(*Am*) is other than isoleucine; the amino acid at position 1,999(*Am*) is other than tryptophan; the amino acid at position 2,027(*Am*) is other than tryptophan; the amino acid at position 2,041(*Am*) is other than isoleucine; the amino acid at position 2,078(*Am*) is other than aspartate; the amino acid at position 2088(*Am*) is other than cysteine; or the amino acid at position 2,096(*Am*) is other than glycine. In some embodiments, a plant grown from a seed of the invention may express an acetyl-Coenzyme A carboxylase enzyme comprising an amino acid sequence that comprises one or more of the following: the amino acid at position 1,781(*Am*) is leucine or alanine; the amino acid at position 1,999(*Am*) is cysteine; the amino acid at position 2,027(*Am*) is cysteine; the amino acid at position 2,041(*Am*) is asparagine; the amino acid at position 2,078(*Am*) is glycine; the amino acid at position 2088(*Am*) is arginine or the amino acid at position 2,096(*Am*) is alanine.

[0019] The present invention encompasses seeds of specific cultivars. One example of such seeds is a seed of rice cultivar Indica1, wherein a representative sample of seed of said cultivar was deposited under ATCC Accession No. PTA-10267. The present invention also encompasses a rice plant, or a part thereof, produced by growing the seeds as well as a tissue culture of cells produced from the seed. Tissue cultures of cells may be produced from a seed directly or from a part of a plant grown from a seed, for example, from the leaves, pollen, embryos, cotyledons, hypocotyls, meristematic cells, roots, root tips, pistils, anthers, flowers and/or stems. The present invention also includes plants and their progeny that have been generated from tissue cultures of cells. Such plants will typically have all the morphological and physiological characteristics of cultivar Indica1.

[0020] The present invention also provides methods for producing rice seed. Such methods may comprise crossing an herbicide-tolerant rice plant with other rice germplasm; and harvesting the resulting hybrid rice seed, wherein the herbicide-tolerant rice plant is tolerant to aryloxyphenoxypropionate herbicides, cyclohexanedione herbicides,

phenylpyrazoline herbicides or combinations thereof at levels of herbicide that would normally inhibit the growth of a rice plant.

[0021] The present method also comprises methods of producing F1 hybrid rice seed. Such methods may comprise crossing an herbicide-tolerant rice plant with a different rice plant; and harvesting the resultant F1 hybrid rice seed, wherein the herbicide-tolerant rice plant is tolerant to aryloxyphenoxypropionate herbicides, cyclohexanedione herbicides, phenylpyrazoline herbicides or combinations thereof at levels of herbicide that would normally inhibit the growth of a rice plant.

[0022] The present invention also provides methods of producing herbicide-tolerant rice plants that may also comprise a transgene. One example of such a method may comprise transforming a cell of a rice plant with a transgene, wherein the transgene encodes an acetyl-Coenzyme A carboxylase enzyme that confers tolerance to at least one herbicide is selected from the group consisting of aryloxyphenoxypropionate herbicides, cyclohexanedione herbicides, phenylpyrazoline herbicides or combinations thereof. Any suitable cell may be used in the practice of the methods of the invention, for example, the cell may be in the form of a callus. In some embodiments, the transgene may comprise a nucleic acid sequence encoding an amino acid sequence comprising a modified version of one or both of SEQ ID NOs: 2 and 3, wherein the sequence is modified such that the encoded protein comprises one or more of the following: the amino acid at position 1,781(*Am*) is leucine or alanine; the amino acid at position 1,999(*Am*) is cysteine; the amino acid at position 2,027(*Am*) is cysteine; the amino acid at position 2,041(*Am*) is asparagine; the amino acid at position 2,078(*Am*) is glycine; the amino acid at position 2088(*Am*) is arginine or the amino acid at position 2,096(*Am*) is alanine. The present invention also encompasses plants produced by such methods. Another example of a method of producing an herbicide-tolerant plant comprising a transgene may comprise transforming a cell of a rice plant with a transgene encoding an enzyme that confers herbicide tolerance, wherein the cell was produced from a rice plant or seed thereof expressing an acetyl-Coenzyme A carboxylase enzyme that confers tolerance to at least one herbicide is selected from the group consisting of aryloxyphenoxypropionate herbicides, cyclohexanedione herbicides, phenylpyrazoline herbicides or combinations thereof. Any suitable cell may be used in the practice of the

methods of the invention, for example, the cell may be in the form of a callus. The present invention also encompasses herbicide-tolerant plants produced by such methods.

[0023] In one embodiment, the present invention comprises methods of producing recombinant plants. An example of a method for producing a recombinant rice plant may comprise transforming a cell of a rice plant with a transgene, wherein the cell was produced from a rice plant expressing an acetyl-Coenzyme A carboxylase enzyme that confers tolerance to at least one herbicide is selected from the group consisting of aryloxyphenoxypropionate herbicides, cyclohexanedione herbicides, phenylpyrazoline herbicides or combinations thereof. Any suitable cell may be used in the practice of the methods of the invention, for example, the cell may be in the form of a callus. A transgene for use in the methods of the invention may comprise any desired nucleic acid sequence, for example, the transgene may encode a protein. In one example, the transgene may encode an enzyme, for example, an enzyme that modifies fatty acid metabolism and/or carbohydrate metabolism. Examples of suitable enzymes include but are not limited to, fructosyltransferase, levansucrase, alpha-amylase, invertase and starch branching enzyme or encoding an antisense of stearyl-ACP desaturase. The present invention also encompasses recombinant plants produced by methods of the invention.

[0024] Methods of the invention may be used to produce a plant, e.g., a rice plant, having any desired traits. An example of such a method may comprise: (a) crossing a rice plant that is tolerant to aryloxyphenoxypropionate herbicides, cyclohexanedione herbicides, phenylpyrazoline herbicides or combinations thereof at levels of herbicide that would normally inhibit the growth of a rice plant with a plant of another rice cultivar that comprises the desired trait to produce progeny plants; (b) selecting one or more progeny plants that have the desired trait to produce selected progeny plants; (c) crossing the selected progeny plants with the herbicide-tolerant plants to produce backcross progeny plants; (d) selecting for backcross progeny plants that have the desired trait and herbicide tolerance; and (e) repeating steps (c) and (d) three or more times in succession to produce selected fourth or higher backcross progeny plants that comprise the desired trait and herbicide tolerance. Any desired trait may be introduced using the methods of the invention. Examples of traits that may be desired include, but are not limited to, male sterility, herbicide tolerance, drought

tolerance insect resistance, modified fatty acid metabolism, modified carbohydrate metabolism and resistance to bacterial disease, fungal disease or viral disease. An example of a method for producing a male sterile rice plant may comprise transforming a rice plant tolerant to at least one herbicide that inhibits acetyl-Coenzyme A carboxylase activity at levels of herbicide that would normally inhibit the growth of a rice plant with a nucleic acid molecule that confers male sterility. The present invention also encompasses male sterile plants produced by such methods.

[0025] The present invention provides compositions comprising plant cells, for example, cells from a rice plant. One example of such a composition comprises one or more cells of a rice plant; and an aqueous medium, wherein the medium comprises a compound that inhibits acetyl-Coenzyme A carboxylase activity. In some embodiments, the cells may be derived from a rice plant tolerant to aryloxyphenoxypropionate herbicides, cyclohexanedione herbicides, phenylpyrazoline herbicides or combinations thereof at levels of herbicide that would normally inhibit the growth of a rice plant. Any compound that inhibits acetyl-Coenzyme A carboxylase activity may be used in the compositions of the invention, for example, one or more of aryloxyphenoxypropionate herbicides, cyclohexanedione herbicides, phenylpyrazoline herbicides and combinations thereof.

[0026] The present invention comprises nucleic acid molecules encoding all or a portion of an acetyl-Coenzyme A carboxylase enzyme. In some embodiments, the invention comprises a recombinant, mutagenized, synthetic, and/or isolated nucleic acid molecule encoding a rice acetyl-Coenzyme A carboxylase (ACCase) in which the amino acid sequence differs from an amino acid sequence of an acetyl-Coenzyme A carboxylase of a wild-type rice plant at one or more of the following positions: 1,781(*Am*), 1,999(*Am*), 2,027(*Am*), 2,041(*Am*), 2,078(*Am*), 2088(*Am*) or 2,096(*Am*). Examples of differences at these amino acid positions include, but are not limited to, one or more of the following: the amino acid at position 1,781(*Am*) is other than isoleucine; the amino acid at position 1,999(*Am*) is other than tryptophan; the amino acid at position 2,027(*Am*) is other than tryptophan; the amino acid at position 2,041(*Am*) is other than isoleucine; the amino acid at position 2,078(*Am*) is other than aspartate; the amino acid at position 2088(*Am*) is other than cysteine; or the amino acid at position 2,096(*Am*) is other than glycine. In some embodiments, a nucleic acid

molecule of the invention may encode an acetyl-Coenzyme A carboxylase enzyme comprising an amino acid sequence that comprises one or more of the following: the amino acid at position 1,781(*Am*) is leucine or alanine; the amino acid at position 1,999(*Am*) is cysteine; the amino acid at position 2,027(*Am*) is cysteine; the amino acid at position 2,041(*Am*) is asparagine; the amino acid at position 2,078(*Am*) is glycine; the amino acid at position 2088(*Am*) is arginine or the amino acid at position 2,096(*Am*) is alanine. In some embodiments, the invention comprises a recombinant, mutagenized, synthetic, and/or isolated encoding a protein comprising all or a portion of a modified version of one or both of SEQ ID NOs: 2 and 3, wherein the sequence is modified such that the encoded protein comprises one or more of the following: the amino acid at position 1,781(*Am*) is leucine or alanine; the amino acid at position 1,999(*Am*) is cysteine; the amino acid at position 2,027(*Am*) is cysteine; the amino acid at position 2,041(*Am*) is asparagine; the amino acid at position 2,078(*Am*) is glycine; the amino acid at position 2088(*Am*) is arginine or the amino acid at position 2,096(*Am*) is alanine.

[0027] In one embodiment, the present invention provides an herbicide-tolerant, BEP clade plant. Typically such a plant is one having increased tolerance to an ACCase-inhibitor (ACCI) as compared to a wild-type variety of the plant. Such plants may be produced by a process comprising either:

(I) the steps of

- (a) providing BEP clade plant cells having a first, zero or non-zero level of ACCI tolerance;
- (b) growing the cells in contact with a medium to form a cell culture;
- (c) contacting cells of said culture with an ACCI;
- (d) growing ACCI-contacted cells from step (c) to form a culture containing cells having a level of ACCI tolerance greater than the first level of step (a); and
- (e) generating, from ACCI-tolerant cells of step (d), a plant having a level of ACCI tolerance greater than that of a wild-type variety of the plant; or

(II) the steps of

- (f) providing a first, herbicide-tolerant, BEP clade plant having increased tolerance to an ACCase-inhibitor (ACCI) as compared to a wild-type

variety of the plant, said herbicide-tolerant plant having been produced by a process comprising steps (a)-(e); and

- (g) producing from the first plant a second, herbicide-tolerant, BEP clade plant that retains the increased herbicide tolerance characteristics of the first plant;

thereby obtaining an herbicide-tolerant, BEP clade plant. In some embodiments, an herbicide-tolerant plant of the invention may be a member of the Bambusoideae - Ehrhartoideae subclade. Any suitable medium for growing plant cells may be used in the practice of the invention. In some embodiments, the medium may comprise a mutagen while in other embodiments the medium does not comprise a mutagen. In some embodiments, an herbicide-tolerant plant of the invention may be a member of the subfamily Ehrhartoideae. Any suitable cells may be used in the practice of the methods of the invention, for example, the cells may be in the form of a callus. In some embodiments, an herbicide-tolerant plant of the invention may be a member of the genus *Oryza*, for example, may be a member of the species *O. sativa*.

[0028] The present invention includes herbicide-tolerant BEP clade plants produced by the above method. Such herbicide-tolerant plants may express an acetyl-Coenzyme A carboxylase (ACCase) in which the amino acid sequence differs from an amino acid sequence of an acetyl-Coenzyme A carboxylase of a corresponding wild-type BEP clade plant at one or more of the following positions: 1,781(*Am*), 1,999(*Am*), 2,027(*Am*), 2,041(*Am*), 2,078(*Am*), 2088(*Am*) or 2,096(*Am*). Examples of differences at these amino acid positions include, but are not limited to, one or more of the following: the amino acid at position 1,781(*Am*) is other than isoleucine; the amino acid at position 1,999(*Am*) is other than tryptophan; the amino acid at position 2,027(*Am*) is other than tryptophan; the amino acid at position 2,041(*Am*) is other than isoleucine; the amino acid at position 2,078(*Am*) is other than aspartate; the amino acid at position 2088(*Am*) is other than cysteine; or the amino acid at position 2,096(*Am*) is other than glycine. In some embodiments, an herbicide-tolerant BEP clade plant of the invention may express an acetyl-Coenzyme A carboxylase enzyme comprising an amino acid sequence that comprises one or more of the following: the amino acid at position 1,781(*Am*) is leucine or alanine; the amino acid at position 1,999(*Am*) is

cysteine; the amino acid at position 2,027(*Am*) is cysteine; the amino acid at position 2,041(*Am*) is asparagine; the amino acid at position 2,078(*Am*) is glycine; the amino acid at position 2088(*Am*) is arginine or the amino acid at position 2,096(*Am*) is alanine.

[0029] The present invention also encompasses herbicide-tolerant BEP clade plants produced by the process of (a) crossing or back-crossing a plant grown from a seed of an herbicide-tolerant BEP clade plant produced as described above with other germplasm; (b) growing the plants resulting from said crossing or back-crossing in the presence of at least one herbicide that normally inhibits acetyl-Coenzyme A carboxylase, at levels of the herbicide that would normally inhibit the growth of a plant; and (c) selecting for further propagation plants resulting from said crossing or back-crossing, wherein the plants selected are plants that grow without significant injury in the presence of the herbicide.

[0030] The present invention also encompasses a recombinant, mutagenized, synthetic, and/or isolated nucleic acid molecule comprising a nucleotide sequence encoding a mutagenized acetyl-Coenzyme A carboxylase of a plant in the BEP clade of the Family Poaceae, in which the amino acid sequence of the mutagenized acetyl-Coenzyme A carboxylase differs from an amino acid sequence of an acetyl-Coenzyme A carboxylase of the corresponding wild-type plant at one or more of the following positions: 1,781(*Am*), 1,999(*Am*), 2,027(*Am*), 2,041(*Am*), 2,078(*Am*), 2088(*Am*) or 2,096(*Am*). Such a nucleic acid molecule may be produced by a process comprising either:

(I) the steps of

- (a) providing BEP clade plant cells having a first, zero or non-zero level of ACCase-inhibitor (ACCI) tolerance;
- (b) growing the cells in contact with a medium to form a cell culture;
- (c) contacting cells of said culture with an ACCI;
- (d) growing ACCI-contacted cells from step (c) to form a culture containing cells having a level of ACCI tolerance greater than the first level of step (a); and
- (e) generating, from ACCI-tolerant cells of step (d), a plant having a level of ACCI tolerance greater than that of a wild-type variety of the plant; or

(II) the steps of

- (f) providing a first, herbicide-tolerant, BEP clade plant having increased tolerance to an ACCase-inhibitor (ACCI) as compared to a wild-type variety of the plant, said herbicide-tolerant plant having been produced by a process comprising steps (a)-(e); and
- (g) producing from the first plant a second, herbicide-tolerant, BEP clade plant that retains the increased herbicide tolerance characteristics of the first plant;

thereby obtaining an herbicide-tolerant, BEP clade plant; and
isolating a nucleic acid from the herbicide-tolerant BEP clade plant.

BRIEF DESCRIPTION OF THE DRAWINGS

- [0031] Figure 1 is a bar graph showing relative growth rice calli derived from *Oryza sativa* subsp. *indica* grown in the presence of difference selection levels of herbicide. Figure 1A shows the results obtained with tepraloxymid, Figure 1B shows the results obtained with sethoxydim, and Figure 1C shows the results obtained with cycloxydim.
- [0032] Figure 2 is a diagram of the selection process used to produce herbicide-tolerant rice plants.
- [0033] Figure 3 shows photographs of plants taken one week after treatment with herbicide.
- [0034] Figure 4 shows photographs of plants taken two weeks after treatment with herbicide.
- [0035] Figure 5 provides the GenBank record for acetyl-coenzyme A carboxylase from *Alopecurus myosuroides* accession number CAC84161.
- [0036] Figure 6 provides the GenBank record for the mRNA encoding acetyl-coenzyme A carboxylase from *Alopecurus myosuroides* accession number AJ310767 region: 157..7119.
- [0037] Figure 7A provides the nucleotide sequence encoding *Oryza sativa* Indica acetyl-Coenzyme A carboxylase (SEQ ID NO:5).
- [0038] Figure 7B provides the amino acid sequence of *Oryza sativa* Indica acetyl-Coenzyme A carboxylase (SEQ ID NO:3).

- [0039] Figure 8A provides the nucleotide sequence encoding *Oryza sativa* Japonica acetyl-Coenzyme A carboxylase (SEQ ID NO:6).
- [0040] Figure 8B provides the amino acid sequence of *Oryza sativa* Japonica acetyl-Coenzyme A carboxylase (SEQ ID NO:3).
- [0041] Figure 9A provides the nucleotide sequence encoding *Zea mays* acetyl-Coenzyme A carboxylase (SEQ ID NO:11).
- [0042] Figure 9B provides the amino acid sequence of *Zea mays* acetyl-Coenzyme A carboxylase (SEQ ID NO:12).
- [0043] Figure 10A provides the nucleotide sequence encoding *Zea mays* acetyl-Coenzyme A carboxylase (SEQ ID NO:13).
- [0044] Figure 10B provides the amino acid sequence of *Zea mays* acetyl-Coenzyme A carboxylase (SEQ ID NO:14).
- [0045] Figure 11A provides the nucleotide sequence encoding *Triticum aestivum* acetyl-Coenzyme A carboxylase (SEQ ID NO:15).
- [0046] Figure 11B provides the amino acid sequence of *Triticum aestivum* acetyl-Coenzyme A carboxylase (SEQ ID NO:16).
- [0047] Figure 12A provides the nucleotide sequence encoding *Setaria italica* acetyl-Coenzyme A carboxylase (SEQ ID NO:17).
- [0048] Figure 12B provides the amino acid sequence of *Setaria italica* acetyl-Coenzyme A carboxylase (SEQ ID NO:18).
- [0049] Figure 13A provides the nucleotide sequence encoding *Setaria italica* acetyl-Coenzyme A carboxylase (SEQ ID NO:19).
- [0050] Figure 13B provides the amino acid sequence of *Setaria italica* acetyl-Coenzyme A carboxylase (SEQ ID NO:20).
- [0051] Figure 14A provides the nucleotide sequence encoding *Setaria italica* acetyl-Coenzyme A carboxylase (SEQ ID NO:21).

[0052] Figure 14B provides the amino acid sequence of *Setaria italica* acetyl-Coenzyme A carboxylase (SEQ ID NO:22).

[0053] Figure 15A provides the nucleotide sequence encoding *Alopecurus myosuroides* acetyl-Coenzyme A carboxylase (SEQ ID NO:23).

[0054] Figure 15B provides the amino acid sequence of *Alopecurus myosuroides* acetyl-Coenzyme A carboxylase (SEQ ID NO:24).

[0055] Figure 16A provides the nucleotide sequence encoding *Aegilops tauschii* acetyl-Coenzyme A carboxylase (SEQ ID NO:).

[0056] Figure 16B provides the amino acid sequence of *Aegilops tauschii* acetyl-Coenzyme A carboxylase (SEQ ID NO:).

DETAILED DESCRIPTION OF THE INVENTION

[0057] Definitions

[0058] As used herein, “tolerant” or “herbicide-tolerant” indicates a plant or portion thereof capable of growing in the presence of an amount of herbicide that normally causes growth inhibition in a non-tolerant (e.g., a wild-type) plant or portion thereof. Levels of herbicide that normally inhibit growth of a non-tolerant plant are known and readily determined by those skilled in the art. Examples include the amounts recommended by manufacturers for application. The following table contains a list of herbicides with the maximum rate of herbicide that is typically applied. The maximum rate is an example of an amount of herbicide that would normally inhibit growth of a non-tolerant plant.

Table 1 List of Herbicides

ACCase Inhibitor	Class	Company	Example Trade Names	Red Rice Control	Maximum Rate [g ai/ha]	Use
aloxymidim	DIM	BASF	Fervin, Kusagard, NP-48Na, BAS 9021H	Good	1000	POST
butoxydim	DIM	Syngenta	Falcon, ICI-A0500	Good	75	POST
clethodim	DIM	Valent	Select, Prsim, RE-45601	Good	280	POST
clodinafop-propargyl	FOP	Syngenta	Discover, Topik, CGA 184 927	Unsure	80	POST
cycloxydim	DIM	BASF	Focus, Laser, Stratos, BAS 517H	Good	448	POST
cyhalofop-butyl	FOP	Dow	Clincher, XDE 537, DEH	None	310	POST

			112			
diclofop-methyl	FOP	Bayer	Hoegrass, Hoelon, Illoxan, HOE 23408	Good	1120	POST
fenoxaprop-P-ethyl	FOP	Bayer	Super Whip, Option Super, Exel Super, HOE-46360, Aclaim, Puma S	Partial	111	POST
fluazifop-P-butyl	FOP	Syngenta	Fusilade, Fusilade 2000, Fusilade DX, ICI-A 0009, ICI-A 0005, SL-236, IH-773B, TF-1169	Good	210	POST
haloxyfop-etotyl	FOP	Dow	Gallant, DOWCO 453EE	Good	600	POST
haloxyfop-methyl	FOP	Dow	Verdict, DOWCO 453ME	Good	600	POST
haloxyfop-P-methyl	FOP	Dow	Edge, DE 535	Good	600	POST
metamifop	FOP	Dongbu	NA	None	201	POST
pinoxaden	DEN	Syngenta	Axial	Good	60	POST
prooxydim	DIM	BASF	Aura, Tetris, BAS 625H	None	212	POST
propaquizafop	FOP	Syngenta	Agil, Shogun, Ro 17-3664	Good	150	POST
quizalofop-P-ethyl	FOP	DuPont	Assure, Assure II, DPX-Y6202-3, Targa Super, NC-302	Good	112	POST
quizalofop-P-tefuryl	FOP	Uniroyal	Pantera, UBI C4874	Good	112	POST
sethoxydim	DIM	BASF	Poast, Poast Plus, NABU, Fervinal, NP-55, Sertin, BAS 562H	Partial	560	POST
tepraloxydim	DIM	BASF	BAS 620H, Aramo	Good	60	POST
tralkoxydim	DIM	Syngenta	Achieve, Splendor, ICI-A0604	Good	3400	POST

[0059] As used herein, "recombinant" refers to an organism having genetic material from different sources.

[0060] As used herein, "mutagenized" refers to an organism having an altered genetic material as compared to the genetic material of a corresponding wild-type organism, wherein the alterations in genetic material were induced and/or selected by human action. Examples of human action that can be used to produce a mutagenized organism include, but are not limited to, tissue culture of plant cells (e.g., calli) in sub-lethal concentrations of herbicides (e.g., acetyl-Coenzyme A carboxylase inhibitors such as cycloxydim or sethoxydim), treatment of plant cells with a chemical mutagen and subsequent selection with herbicides (e.g., acetyl-Coenzyme A carboxylase inhibitors such as cycloxydim or sethoxydim); or by

treatment of plant cells with x-rays and subsequent selection with herbicides (e.g., acetyl-Coenzyme A carboxylase inhibitors such as cycloxydim or sethoxydim). Any method known in the art may be used to induce mutations. Methods of inducing mutations may induce mutations in random positions in the genetic material or may induce mutations in specific locations in the genetic material (i.e., may be directed mutagenesis techniques).

[0061] As used herein, a “genetically modified organism” (GMO) is an organism whose genetic characteristics have been altered by insertion of genetic material from another source organism or progeny thereof that retain the inserted genetic material. The source organism may be of a different type of organism (e.g., a GMO plant may contain bacterial genetic material) or from the same type of organism (e.g., a GMO plant may contain genetic material from another plant). As used herein, recombinant and GMO are considered synonyms and indicate the presence of genetic material from a different source whereas mutagenized indicates altered genetic material from a corresponding wild-type organism but no genetic material from another source organism.

[0062] As used herein, “wild-type” or “corresponding wild-type plant” means the typical form of an organism or its genetic material, as it normally occurs, as distinguished from mutagenized and/or recombinant forms.

[0063] Plants

[0064] The present invention provides herbicide-tolerant monocotyledonous plants of the grass family Poaceae. The family Poaceae may be divided into two major clades, the clade containing the subfamilies Bambusoideae, Ehrhartoideae, and Pooideae (the BEP clade) and the clade containing the subfamilies Panicoideae, Arundinoideae, Chloridoideae, Centothecoideae, Micrairoideae, Aristidoideae, and Danthonioideae (the PACCMAD clade). The present invention relates to plants of the BEP clade, in particular plants of the subfamilies Bambusoideae and Ehrhartoideae. Plants of the invention are typically tolerant to at least one herbicide that inhibits acetyl-Coenzyme A carboxylase activity as a result of expressing an acetyl-Coenzyme A carboxylase enzyme of the invention as described below.

[0065] In one embodiment, the present invention provides herbicide-tolerant plants of the Bambusoideae subfamily. Such plants are typically tolerant to one or more herbicides that inhibit acetyl-Coenzyme A carboxylase activity. Examples of herbicide-tolerant plants of the

subfamily Bambusoideae include, but are not limited to, those of the genera *Arundinaria*, *Bambusa*, *Chusquea*, *Guadua*, and *Shibataea*.

[0066] In one embodiment, the present invention provides herbicide-tolerant plants of the Ehrhartoideae subfamily. Such plants are typically tolerant to one or more herbicides that inhibit acetyl-Coenzyme A carboxylase activity. Examples of herbicide-tolerant plants of the subfamily Ehrhartoideae include, but are not limited to, those of the genera *Erharta*, *Leersia*, *Microlaena*, *Oryza*, and *Zizania*.

[0067] In one embodiment, herbicide-tolerant plants of the invention are rice plants. Two species of rice are most frequently cultivated, *Oryza sativa* and *Oryza glaberrima*. Numerous subspecies of *Oryza sativa* are commercially important including *Oryza sativa* subsp. *indica*, *Oryza sativa* subsp. *japonica*, *Oryza sativa* subsp. *javanica*, *Oryza sativa* subsp. *glutinosa* (glutinous rice), *Oryza sativa* Aromatica group (basmati), and *Oryza sativa* Floating rice group. The present invention encompasses herbicide-tolerant plants in all of the aforementioned species and subspecies.

[0068] In addition to being able to tolerate herbicides that inhibit acetyl-Coenzyme A carboxylase activity, plants of the invention may also be able to tolerate herbicides that work on other physiological processes. For example, plants of the invention may be tolerant to acetyl-Coenzyme A carboxylase inhibitors and also tolerant to other herbicides, for example, enzyme inhibitors. Examples of other enzyme inhibitors to which plants of the invention may be tolerant include, but are not limited to, inhibitors of 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS) such as glyphosate, inhibitors of acetohydroxyacid synthase (AHAS) such as imidazolinone and sulfonamide herbicides, and inhibitors of glutamine synthase such as glufosinate. In addition to enzyme inhibitors, plants of the invention may also be tolerant of herbicides having other modes of action, for example, auxin growth regulators, chlorophyll/carotenoid pigment inhibitors, cell membrane destroyers, photosynthetic inhibitors, cell division inhibitors, root inhibitors, shoot inhibitors, and combinations thereof.

[0069] The present invention also encompasses progeny of the plants of the invention as well as seeds derived from the herbicide-tolerant plants of the invention and cells derived from the herbicide-tolerant plants of the invention.

[0070] Acetyl-Coenzyme A carboxylase Enzymes

[0071] The present invention provides plants expressing acetyl-Coenzyme A carboxylase enzymes with amino acid sequences that differ from the amino acid sequence of the acetyl-Coenzyme A carboxylase enzyme found in the corresponding wild-type plant. For ease of understanding, the amino acid numbering system used herein will be the numbering system used for the acetyl-Coenzyme A carboxylase from *Alopecurus myosuroides* [Huds.] (also referred to as black grass). The mRNA sequence encoding the *A. myosuroides* acetyl-Coenzyme A carboxylase is available at GenBank accession number AJ310767 and the protein sequence is available at GenBank accession no. CAC84161 both of which are specifically incorporated herein by reference. The number of the amino acid referred to will be followed with (*Am*) to indicate the amino acid in the *Alopecurus myosuroides* sequence to which the amino acid corresponds. The following table provides the amino acid sequence of *Alopecurus myosuroides* acetyl-Coenzyme A carboxylase.

[0072] Table 2 *Alopecurus myosuroides* acetyl-Coenzyme A carboxylase amino acid sequence GenBank accession no. CAC84161. Amino acids that by be altered in the acetyl-Coenzyme A carboxylase enzymes of the invention are indicted in bold double underline.

1	MGSTHLPIVG	FNASTTPSLS	TLRQINSAAA	AFQSSSPSRS	SKKKSRRVKS	IRDDGDGSPV
61	DPAGHGQSIR	QGLAGIIDLP	KEGASAPDVD	ISHGSEDHKA	SYQMNGILNE	SHNGRHASLS
121	KVYEFCTELG	GKTPIHSVLV	ANNMMAAAKF	MRSVRTWAND	TFGSEKAIQL	IAMATPEDMR
181	INAEHIRIAD	QFVEVPGGTN	NNNYANVQLI	VEIAERTGVS	AVWPGWGHAS	ENPELDPALT
241	AKGIVFLGPP	ASSMNALGDK	VGSALIAQAA	GVPTLAWSGS	HVEIPLLELCL	DSIPEEMYRK
301	ACVTTADEAV	ASCQMIGYPA	MIKASWGGGG	KGIRKVNND	EVKALFKQVQ	GEVPGSPIFI
361	MRLASQSRHL	EVQLLCDEYG	NVAALHSRDC	SVQRRHQKII	EEGPVTVAPR	ETVKELEQAA
421	RRLAKAVGYV	GAATVEYLYS	METGEYYFLE	LNPRLOVEHP	VTESIAEVNL	PAAQVAVGMG
481	IPLWQIPEIR	RFYGMNNGGG	YDIWRKTAAL	ATPFNFDEVD	SQWPKGHCVA	VRITSENPPD
541	GFKPTGGKVK	EISFKSKPNV	WGYFSVKSGG	GIHEFADSQF	GHVFAVGETR	SAAITSMSLA
601	LKEIQIRGEI	HTNVDYTVDL	LNAPDFRENT	IHTGWLDTRI	AMRVQAERPP	WYISVVGGAL
661	YKTITTTNAET	VSEYVSYLIK	GQIPPKHISL	VHSTISLNIE	ESKYTIEIVR	SGQGSYRLRL
721	NGSLIEANVQ	TLCDGGLLMQ	LDGNSHVIYA	EEEAGGTRLL	IDGKTCLLQN	DHDPSSRLLAE
781	TPCKLLRFLI	ADGAHVADAV	PYAEVEVMKM	CMPLLSPAAG	VINVLLSEGO	AMQAGDLIAR
841	LDLDDPSAVK	RAEPFEGSFP	EMSLPIAASG	QVHKRCAASL	NAARMVLAGY	DHAANKVVQD
901	LVWCLDTPAL	PFLQWHEELMS	VLATRLPRRL	KSELEGKYNE	YKLNVDHVKI	KDFPTEMLRE
961	TIEENLACVS	EKEMVTIERL	VDPLMSLLKS	YEGGRESHAH	FIVKSLFEEY	LSVEELFSDG
1021	IQSDVIERLR	LQYSKDLQKV	VDIVLSHQGV	RNKTKLILAL	MEKLVYPNPA	AYRDQLIRFS
1081	SLNHKRYRYKL	ALKASELLEQ	TKLSELRTSI	ARNLSALDMF	TEEKADFSLO	DRKLAINESM
1141	GDLVTAPLPV	EDALVSLFDC	TDQTLQQRVI	QTYISRLYQP	QLVKDSIQLK	YQDSGVIALW
1201	EFTEGNHEKR	LGAMVILKSL	ESVSTAIGAA	LKDASHYASS	AGNTVHIALL	DADTQLNTE
1261	DSGDNDQAQD	KMDKLSFVLK	QDVVMADLRA	ADVKKVVCIV	QRDGAIMPMPR	RTFLLSSEKL
1321	CYEEEPILRH	VEPPLSALLE	LDKLVKVGYN	EMKYTPSRDR	QWHIYTLRNT	ENPKMLHRVF
1381	FRTLVRQPSA	GNRFTSDHIT	DVEVGHAEAP	LSFTSSSILK	SLKIAKEELE	LHAIRTGHSH
1441	MYLCILKEQK	LLDLVPVSGN	TVVDVGQDEA	TACSLLKEMA	LKIHVGVGAR	MHLSVCQWE
1501	VKLKLVSDGP	ASGSRVVVTT	NVTGHTCTVD	IYREVEDTES	QKLVYHSTAL	SSGPLHGVAL

1561 NTSYQPLSVI DLKRCSARNN KTTYCYDFPL TFEAAVQKSW SNISSENNQC YVKATELVFA
 1621 EKNGSWGTP I PMQRAAGLN DIGMVAWILD MSTPEFPSPGR QIIVIANIT FRAGSFGPRE
 1681 DAFFEAVTNL ACEKKLPLIY LAANSGARIG IADEVKSCFR VGWTDSSPE RGFRIYMTD
 1741 EDHDRIGSSV IAHKMLDSG EIRWVIDSVV GKEDGLGVEN IHGSAIASA YSRAYEETFT
 1801 LTFVTGRTVG IGAYLARLGI RCIQRIDQPI ILTGFSALNK LLGREVYSSH MQLGGPKIMA
 1861 TNGVVHLTVP DDLEGVSNIL RWLSYVPANI GGPLPITKSL DPIDRPVAYI PENTCDPRAA
 1921 ISGIDDSQ GK WLGGMFDKDS FVETFEGWAK TVVTGRAKLG GIPVGVIAVE TQTMQLVPA
 1981 DPGQPD SHER SVPRAGQVWF PDSATKTAQA MLDFNREGLP LFI LANWRGF SGGQDLFEG
 2041 ILQAGSTIVE NLR TYNQPAF VYIPKAAELR GGAWVIDSK INPDRIE CYA ERTAKGNVLE
 2101 PQGLIEIKFR SEELKECMGR LDPELIDLKA RLQANGSL S DGESLQKSIE ARKKQLLPLY
 2161 TQLAVRFAEL HDTSLRMAAK GVIRKVDWE DSR SFFYKRL RRRLSEDLA KEIRGVIGEK
 2221 FPHKSAIELI KKWYLASEAA AAGSTDWDD DAFVAWREN P ENYKEYIKEL RAQRVSRLLS
 2281 DVAGSSSDLQ ALPQGLSMLL DKMDPSKRAQ FIEEVMKVLK

[0073] The amino acid sequences of wild-type *Oryza sativa* Indica (OSI) and *Oryza sativa* Japonica (OSJ) acetyl-Coenzyme A carboxylase is provided in the following table.

[0074] Table 3 Amino acid sequence of wild-type *Oryza sativa* acetyl-Coenzyme A carboxylases aligned with *Alopecurus myosuroides* acetyl-Coenzyme A carboxylase with critical residues denoted.

Table 2	1	60
AmACCI [CAC84161]	(1) MGSTHLPVGFNASTP	SLSTRQINSAAA
OSIACCI [BGIOSIBCE018385]	(1) MTSTHVATLGVGAQAPRHQ---	KKSAGTAFVSSGSSRPSYRKNGQRT
OsJACCI [EAZ33685]	(1) MTSTHVATLGVGAQAPRHQ---	KKSAGTAFVSSGSSRPSYRKNGQRT
	61	120
AmACCI [CAC84161]	(61) DPAGHGQSIRQGLAGIIDL	PKEGASAPDVIDSHGSEDHKA----
OSIACCI [BGIOSIBCE018385]	(58) DSKKLNHSIRQGLAGIIDL	PNDAAS--EVDISHGSEDPRGPTV
OsJACCI [EAZ33685]	(58) DSKKLNHSIRQGLAGIIDL	PNDAAS--EVDISHGSEDPRGPTV
	121	180
AmACCI [CAC84161]	(116) HASLSKVVEFCTELG	GKTPHISVSVANNGMAAAKFMRSVRT
OSIACCI [BGIOSIBCE018385]	(116) HASVSKVVEFCTALG	GKTPHISVSVANNGMAAAKFMRSVRT
OsJACCI [EAZ33685]	(116) HASVSKVVEFCTALG	GKTPHISVSVANNGMAAAKFMRSVRT
	181	240
AmACCI [CAC84161]	(176) PEDMRINAEHIRIADQ	FVEVPGGTNNNNYANVQLIVEIAERT
OSIACCI [BGIOSIBCE018385]	(176) PEDLRINAEHIRIADQ	FVEVPGGTNNNNYANVQLIVEIAERT
OsJACCI [EAZ33685]	(176) PEDLRINAEHIRIADQ	FVEVPGGTNNNNYANVQLIVEIAERT
	241	300
AmACCI [CAC84161]	(236) PDALTAKGIVFLGPP	ASSMHALGDKVGSALIAQAAGVPT
OSIACCI [BGIOSIBCE018385]	(236) PDALTAKGIVFLGPP	ASSMHALGDKVGSALIAQAAGVPT
OsJACCI [EAZ33685]	(236) PDALTAKGIVFLGPP	ASSMHALGDKVGSALIAQAAGVPT
	301	360
AmACCI [CAC84161]	(296) EMYRKACVTTADEAV	ASCQMIQY PAMIKASWGGGGK
OSIACCI [BGIOSIBCE018385]	(296) EMYRKACVTTTEEAV	ASCQVVGYPAMIKASWGGGGK

OsJACCI [EAZ33685]	(296)	EMYRKACVTTTTEEAVASCQVVGYPAMIKASWGGGKIRKVNDDDEVRTLKQVQGEVPG	
		361	420
AmACCI [CAC84161]	(356)	SPIFIMRLASQSRHLEVQLLCDQYGNVAALHSRDCSVQRRHQKIIIEGPTVAPRETVKE	
OSIACCI [BGIOSIBCE018385]	(356)	SPIFIMRLAAQSRHLEVQLLCDQYGNVAALHSRDCSVQRRHQKIIIEGPTVAPRETVKE	
OsJACCI [EAZ33685]	(356)	SPIFIMRLAAQSRHLEVQLLCDQYGNVAALHSRDCSVQRRHQKIIIEGPTVAPRETVKE	
		421	480
AmACCI [CAC84161]	(416)	LEQAARRLAKAVGYVGAATVEYLYSMETGEYYFLELNPRLQVEHPVTEIAEVNLPAAQV	
OSIACCI [BGIOSIBCE018385]	(416)	LEQAARRLAKAVGYVGAATVEYLYSMETGEYYFLELNPRLQVEHPVTEWIAEVNLPAAQV	
OsJACCI [EAZ33685]	(416)	LEQAARRLAKAVGYVGAATVEYLYSMETGEYYFLELNPRLQVEHPVTEWIAEVNLPAAQV	
		481	540
AmACCI [CAC84161]	(476)	AVGMGIPLWQIPEIRRFYGMNNGGGYDIWRKTAALATPFNFDEVDSQWPKGHCVAVRITS	
OSIACCI [BGIOSIBCE018385]	(476)	AVGMGIPLWQIPEIRRFYGMNHGGYDLWRKTAALATPFNFDEVDSKWPKGHCVAVRITS	
OsJACCI [EAZ33685]	(476)	AVGMGIPLWQIPEIRRFYGMNHGGYDLWRKTAALATPFNFDEVDSKWPKGHCVAVRITS	
		541	600
AmACCI [CAC84161]	(536)	ENPDDGFKPTGGKVKEISFKSKPNVWGYFSVKSGGGIHEFADSQFGHVFAYGTRSAAIT	
OSIACCI [BGIOSIBCE018385]	(536)	EDPDDGFKPTGGKVKEISFKSKPNVWAYFSVKSGGGIHEFADSQFGHVFAYGTRSAAIT	
OsJACCI [EAZ33685]	(536)	EDPDDGFKPTGGKVKEISFKSKPNVWAYFSVKSGGGIHEFADSQFGHVFAYGTRSAAIT	
		601	660
AmACCI [CAC84161]	(596)	SMSLALKEIQIRGEIHTNVDYTVDLLNAPDFRENTIHTGWLDTRIAMRVQAERPPWYISV	
OSIACCI [BGIOSIBCE018385]	(596)	TMALALKEVQIRGEIHSNVDYTVDLLNASDFRENKIHTGWLDTRIAMRVQAERPPWYISV	
OsJACCI [EAZ33685]	(596)	TMALALKEVQIRGEIHSNVDYTVDLLNASDFRENKIHTGWLDTRIAMRVQAERPPWYISV	
		661	720
AmACCI [CAC84161]	(656)	VGGALYKTITTTNAETVSEYVSYLKIQIPPKHISLVHSTISLNIEESKYTIEIVRSGQGS	
OSIACCI [BGIOSIBCE018385]	(656)	VGGALYKTVTANTATVSDYVGYLTKGQIPPKHISLVYTTVALNIDGKKTIDTVRSGHGS	
OsJACCI [EAZ33685]	(656)	VGGALYKTVTANTATVSDYVGYLTKGQIPPKHISLVYTTVALNIDGKKTIDTVRSGHGS	
		721	780
AmACCI [CAC84161]	(716)	YRLRLNGSLIEANVQTLCDGGLLMQLDGNSHVIYAEEEAGGTRLLIDGKTCMLQNDHDP	
OSIACCI [BGIOSIBCE018385]	(716)	YRLRMNGSTVDANVQILCDGGLLMQLDGNSHVIYAEEEASGTRLLIDGKTCMLQNDHDP	
OsJACCI [EAZ33685]	(716)	YRLRMNGSTVDANVQILCDGGLLMQLDGNSHVIYAEEEASGTRLLIDGKTCMLQNDHDP	
		781	840
AmACCI [CAC84161]	(776)	RLLAETPCKLLRFLVADGAHVADVPYAEVEVMKMCPLLSPAAGVINVLLSEGQAMQAG	
OSIACCI [BGIOSIBCE018385]	(776)	KLLAETPCKLLRFLVADGAHVADVPYAEVEVMKMCPLLSPASGVIHVVMSEGQAMQAG	
OsJACCI [EAZ33685]	(776)	KLLAETPCKLLRFLVADGAHVADVPYAEVEVMKMCPLLSPASGVIHVVMSEGQAMQAG	
		841	900
AmACCI [CAC84161]	(836)	DLIARLDLDDPSAVKRAEPFEGSFPEMSLPIAASGQVHKRCAASLNARMVLAGYDHAAN	
OSIACCI [BGIOSIBCE018385]	(836)	DLIARLDLDDPSAVKRAEPFEDTFPQMGLPIAASGQVHKRCAASLNACRMILAGYEHDID	
OsJACCI [EAZ33685]	(836)	DLIARLDLDDPSAVKRAEPFEDTFPQMGLPIAASGQVHKRCAASLNACRMILAGYEHDID	

	901		960
AmACCI [CAC84161]	(896)	KVVQDLVWCLDTPALPFLQWEELMSVLATRLPRRLKSELEGKYNEYKLVNDHVKIKDFPT	
OSIACCI [BGIOSIBCE018385]	(896)	KVVPPELVYCLDTPPELQWEELMSVLATRLPRNLKSELEGKYEEYKVKFDSGIINDFPA	
OsJACCI [EAZ33685]	(896)	KVVPPELVYCLDTPPELQWEELMSVLATRLPRNLKSELEGKYEEYKVKFDSGIINDFPA	
	961		1020
AmACCI [CAC84161]	(956)	EMLRETIIEENLACVSEKEMVTIERLVDPLMSLLKSYEGGRESHAFIVKSLFEEYLSVEE	
OSIACCI [BGIOSIBCE018385]	(956)	NMLRVIIIEENLACGSEKEKATNERLVEPLMSLLKSYEGGRESHAFVVKSLFEEYLYVEE	
OsJACCI [EAZ33685]	(956)	NMLRVIIIEENLACGSEKEKATNERLVEPLMSLLKSYEGGRESHAFVVKSLFEEYLYVEE	
	1021		1080
AmACCI [CAC84161]	(1016)	LFSDBGIQSDVIERLRLQYSKDLQKVVDIVLSHQSVRNKTKLILALMEKLVYPNPAAYRDQ	
OSIACCI [BGIOSIBCE018385]	(1016)	LFSDBGIQSDVIERLRLQHSKDLQKVVDIVLSHQSVRNKTKLILKLMESLVYPNPAAYRDQ	
OsJACCI [EAZ33685]	(1016)	LFSDBGIQSDVIERLRLQHSKDLQKVVDIVLSHQSVRNKTKLILKLMESLVYPNPAAYRDQ	
	1081		1140
AmACCI [CAC84161]	(1076)	LIRFSSLNHKRYKALKASELLEQTKLSELRTSIARNLSALDMFTEEKADFSLQDRKLA	
OSIACCI [BGIOSIBCE018385]	(1076)	LIRFSSLNHKAYKALKASELLEQTKLSELRARIARSLSELEMFTESKGLSMHKRETA	
OsJACCI [EAZ33685]	(1076)	LIRFSSLNHKAYKALKASELLEQTKLSELRARIARSLSELEMFTESKGLSMHKRETA	
	1141		1200
AmACCI [CAC84161]	(1136)	INESMGDLVTAPLPVEDALVSLFDCTDQTLQQRVIQTYISRLYQPQLVKDSIQLKYQDSG	
OSIACCI [BGIOSIBCE018385]	(1136)	IKESMEDLVTAPLPVEDALISLFDSDTTVQQRVIETYIARLYQPHLVKDSIKMKWIESG	
OsJACCI [EAZ33685]	(1136)	IKESMEDLVTAPLPVEDALISLFDSDTTVQQRVIETYIARLYQPHLVKDSIKMKWIESG	
	1201		1260
AmACCI [CAC84161]	(1196)	VIALWEFTEGNHEKR-----LGAMVILKSLESVSTAIGAALKDASHYASSAGNTV	
OSIACCI [BGIOSIBCE018385]	(1196)	VIALWEFPEGHFDARNGGAVLGDKRWGAMVIVKSLESLSMAIRFALKETSHYTSSEGNMM	
OsJACCI [EAZ33685]	(1196)	VIALWEFPEGHFDARNGGAVLGDKRWGAMVIVKSLESLSMAIRFALKETSHYTSSEGNMM	
	1261		1320
AmACCI [CAC84161]	(1246)	HIALLDADTQLNTTEDSGDNDQAQDKMDKLSFVLKQDVVMADLRAADVKKVSCIVQRDGA	
OSIACCI [BGIOSIBCE018385]	(1256)	HIALLGADNMKMHIIQESG---DDADRIAKLPLILKDN--VTDLHASGVKTTISFIVQRDEA	
OsJACCI [EAZ33685]	(1256)	HIALLGADNMKMHIIQESG---DDADRIAKLPLILKDN--VTDLHASGVKTTISFIVQRDEA	
	1321		1380
AmACCI [CAC84161]	(1306)	IMPMRRTFLLSEEKLCYEEEPILRHVEPPLSALLELDKLVKGYNEMKYTPSRDRQWHIY	
OSIACCI [BGIOSIBCE018385]	(1311)	RMTMRRTFLWSDEKLSYEEEPILRHVEPPLSALLELDKLVKGYNEMKYTPSRDRQWHIY	
OsJACCI [EAZ33685]	(1311)	RMTMRRTFLWSDEKLSYEEEPILRHVEPPLSALLELDKLVKGYNEMKYTPSRDRQWHIY	
	1381		1440
AmACCI [CAC84161]	(1366)	TLRNTENPKMLHRVFFRTLVRQPSAGNRFTSDHITDVEVGHAEPLSFTSSSILKSLKIA	
OSIACCI [BGIOSIBCE018385]	(1371)	TLRNTENPKMLHRVFFRTLVRQPSVSNKFSSGQIGDMEVGSAAEPLSFTSTSILRSLMTA	
OsJACCI [EAZ33685]	(1371)	TLRNTENPKMLHRVFFRTLVRQPSVSNKFSSGQIGDMEVGSAAEPLSFTSTSILRSLMTA	
	1441		1500
AmACCI [CAC84161]	(1426)	KEEELHAIRTGHSYMLCIIKEQKLLDLVPVSGNTVVDVVGQDEATACSLKEMALKIHE	

OSIACCI [BGIOSIBCE018385]	(1431)	IEEELHHAIRTGHSHTMLHVLKEQKLLDLVPVSGNTVLDVVGQDEATAYSLKEMAMKIHE	
OsJACCI [EAZ33685]	(1431)	IEEELHHAIRTGHSHTMLHVLKEQKLLDLVPVSGNTVLDVVGQDEATAYSLKEMAMKIHE	
		1501	1560
AmACCI [CAC84161]	(1486)	LVGARMHLSVCQWEVKLKLVDGPGASGSRVVTNVTGHTCTVDIYREVEDTESQKLVY	
OSIACCI [BGIOSIBCE018385]	(1491)	LVGARMHLSVCQWEVKLKLDCDGPASGTWRIVTNTVTSHTCTVDIYREMEDKESRKLVI	
OsJACCI [EAZ33685]	(1491)	LVGARMHLSVCQWEVKLKLDCDGPASGTWRIVTNTVTSHTCTVDIYREMEDKESRKLVI	
		1561	1620
AmACCI [CAC84161]	(1546)	HSTALSSGPLHGVALNTSYQPLSVIDLKRCSARNNKTTYCYDFPLTFEAAVQKSWSNISS	
OSIACCI [BGIOSIBCE018385]	(1551)	HPATPAAGPLHGVALNNPYQPLSVIDLKRCSARNNRTTYCYDFPLAFETAVRKSWSSSSTS	
OsJACCI [EAZ33685]	(1551)	HPATPAAGPLHGVALNNPYQPLSVIDLKRCSARNNRTTYCYDFPLAFETAVRKSWSSSSTS	
		1621	1680
AmACCI [CAC84161]	(1606)	-----ENNQCIVKATELVFAEKNGSWGTPPIIPMQRAAGLNDIGMVAVILDMSTPEFPFSG	
OSIACCI [BGIOSIBCE018385]	(1611)	GASKGVENAQCIVKATELVFADKHGSWGTPLVQMDRPAAGLNDIGMVAVILDMSTPEFPFSG	
OsJACCI [EAZ33685]	(1611)	GASKGVENAQCIVKAT-----ELVQMDRLAGLNDIGMVAVILDMSTPEFLSG	
		1681	1740
AmACCI [CAC84161]	(1660)	RQIIVIANIDITFRAGSFGPREDAFFEAVTNLACEKKLPLIYLAANS GARIGIADEVKSCF	
OSIACCI [BGIOSIBCE018385]	(1671)	REIIVVANDITFRAGSFGPREDAFFEAVTNLACEKKLPLIYLAANS GARIGIADEVKSCF	
OsJACCI [EAZ33685]	(1658)	REIIVVANDITFRAGSFGPREDAFFEAVTNLACEKKLPLIYLAANS GARIGIADEVKSCF	
		1741	1800
AmACCI [CAC84161]	(1720)	RVGWTDDSSPERGFRYIYMTDEDHDRIGSSVIAHKMQLDSGEIRWVIDSVVGKEDGLGVE	
OSIACCI [BGIOSIBCE018385]	(1731)	RVGWSDDGSPERGQYIYLSEEDYARIGTSVIAHKMQLDSGEIRWVIDSVVGKEDGLGVE	
OsJACCI [EAZ33685]	(1718)	RVGWSDDGSPERGQYIYLSEEDYARIGTSVIAHKMQLDSGEIRWVIDSVVGKEDGLGVE	
		1801	1860
AmACCI [CAC84161]	(1780)	NIHGSAAIASAYSRAYEFTFTLTFVTGRTVIGAYLARLGIRCIQRIDQPIILTGYSALN	
OSIACCI [BGIOSIBCE018385]	(1791)	NIHGSAAIASAYSRAYKETFTLTFVTGRTVIGAYLARLGIRCIQRIDQPIILTGYSALN	
OsJACCI [EAZ33685]	(1778)	NIHGSAAIASAYSRAYKETFTLTFVTGRTVIGAYLARLGIRCIQRIDQPIILTGYSALN	
		↑I1781 (Am) L	
		1861	1920
AmACCI [CAC84161]	(1840)	KLLGREVYSSHMQLGGPKIMATNGVVHLTVPDDLEGVSNILRWLSYVPANIGGPLPITKS	
OSIACCI [BGIOSIBCE018385]	(1851)	KLLGREVYSSHMQLGGPKIMATNGVVHLTVSDDLEGVSNILRWLSYVPAYIGGPLPVTTTP	
OsJACCI [EAZ33685]	(1838)	KLLGREVYSSHMQLGGPKIMATNGVVHLTVSDDLEGVSNILRWLSYVPAYIGGPLPVTTTP	
		1921	1980
AmACCI [CAC84161]	(1900)	LDPIDRPVAYIPENTCDPRAAISGIDDSQGKWLGGMFDKDSFVETFEGWAKTVVTGRAKL	
OSIACCI [BGIOSIBCE018385]	(1911)	LDPPDRPVAYIPENSCDPRAAIRGVDDSQGKWLGGMFDKDSFVETFEGWAKTVVTGRAKL	
OsJACCI [EAZ33685]	(1898)	LDPPDRPVAYIPENSCDPRAAIRGVDDSQGKWLGGMFDKDSFVETFEGWAKTVVTGRAKL	
		1981	2040
AmACCI [CAC84161]	(1960)	GGIPVGVIAVETQTMQLVPADPGQPDHERSVPRAGQVWFPSATKTAQAMLDNFNREGL	
OSIACCI [BGIOSIBCE018385]	(1971)	GGIPVGVIAVETQTMQTIPADPGQLDSREQSVPRAGQVWFPSATKTAQALLDNFNREGL	

OsJACCI [EAZ33685]	(1958)	GGIPVGVIAVETQTMQTIPADPGQLDSREQSVPRAGQVWFPSATKTAQALLDFNREGL W1999 (Am) C†	
		2041	2100
AmACCI [CAC84161]	(2020)	PLFILANWRGFSGGQRDLFEGILQAGSTIVENLRTYNQPAFVYIPKAAELRGGAWVVIDS	
OSIACCI [BGIOSIBCE018385]	(2031)	PLFILANWRGFSGGQRDLFEGILQAGSTIVENLRTYNQPAFVYIPMAAELRGGAWVVVDS	
OsJACCI [EAZ33685]	(2018)	PLFILANWRGFSGGQRDLFEGILQAGSTIVENLRTYNQPAFVYIPMAAELRGGAWVVVDS W2027 (Am) C† I2041 (Am) N† D2078 (Am) G†	
		2101	2160
AmACCI [CAC84161]	(2080)	KINPDRIECYAERTAKGNVLEPQGLIEIKFRSEELKECMGRDPELIDLKARLQGAN-GS	
OSIACCI [BGIOSIBCE018385]	(2091)	KINPDRIECYAERTAKGNVLEPQGLIEIKFRSEELQDCMSRLDPTLIDLKAKLEVANKNG	
OsJACCI [EAZ33685]	(2078)	KINPDRIECYAERTAKGNVLEPQGLIEIKFRSEELQDCMSRLDPTLIDLKAKLEVANKNG C2088 (Am) R† †G2096 (Am) A	
		2161	2220
AmACCI [CAC84161]	(2139)	LSDGESLQKSIEARKKQLLPLYTQIAVRFaelHDTSLRMAAGVIRKVVWDWEDSRSFYK	
OSIACCI [BGIOSIBCE018385]	(2151)	SADTKSLQENIEARTKQLMPLYTQIAIRFAELHDTSLRMAAGVIKVVWDWEESSRSFFYK	
OsJACCI [EAZ33685]	(2138)	SADTKSLQENIEARTKQLMPLYTQIAIRFAELHDTSLRMAAGVIKVVWDWEESSRSFFYK	
		2221	2280
AmACCI [CAC84161]	(2199)	RLRRRLSEDLVLAKEIRGVIGEFPHKSAIELIKKWYLASEAAAAGSTDWDDDDAFVAVRE	
OSIACCI [BGIOSIBCE018385]	(2211)	RLRRRISEDLVLAKEIRAVAGEQFSHQPAIELIKKWYSASHAA-----EWDDDDAFVAVMD	
OsJACCI [EAZ33685]	(2198)	RLRRRISEDLVLAKEIRAVAGEQFSHQPAIELIKKWYSASHAA-----EWDDDDAFVAVMD	
		2281	2340
AmACCI [CAC84161]	(2259)	NPENYKEYIKELRAQRVSRLLSDVAGSSDLQALPQGLSMLLDKMDPSKRAQFIEEVMKV	
OSIACCI [BGIOSIBCE018385]	(2266)	NPENYKDYIQYLKAQRVSQSLSSLSLSDSSDLQALPQGLSMLLDKMDPSRRAQLVEEIRKV	
OsJACCI [EAZ33685]	(2253)	NPENYKDYIQYLKAQRVSQSLSSLSLSDSSDLQALPQGLSMLLDKMDPSRRAQLVEEIRKV	
		2341	
AmACCI [CAC84161]	(2319)	LK	
OSIACCI [BGIOSIBCE018385]	(2326)	LG	
OsJACCI [EAZ33685]	(2313)	LG	

[0075] In one embodiment, an acetyl-Coenzyme A carboxylase of the invention differs from the corresponding wild-type acetyl-Coenzyme A carboxylase at amino acid position 1781(Am). Wild-type *A. myosuroides* acetyl-Coenzyme A carboxylase has an isoleucine at position 1781(Am). Acetyl-Coenzyme A carboxylase enzymes of the invention will typically have an amino acid other than isoleucine at this position. Suitable examples of amino acids that may be found at this position in the acetyl-Coenzyme A carboxylase enzymes of the invention include, but are not limited to, leucine and alanine. In one embodiment, an acetyl-Coenzyme A carboxylase enzyme of the invention will have a leucine at 1781(Am).

[0076] In one embodiment, an acetyl-Coenzyme A carboxylase of the invention differs from the corresponding wild-type acetyl-Coenzyme A carboxylase at amino acid position 1999(*Am*). Wild-type *A. myosuroides* acetyl-Coenzyme A carboxylase has a tryptophan at position 1999(*Am*). Acetyl-Coenzyme A carboxylase enzymes of the invention will typically have an amino acid other than tryptophan at this position. Suitable examples of amino acids that may be found at this position in the acetyl-Coenzyme A carboxylase enzymes of the invention include, but are not limited to, cysteine. In one embodiment, an acetyl-Coenzyme A carboxylase enzyme of the invention will have a cysteine at 1999(*Am*).

[0077] In one embodiment, an acetyl-Coenzyme A carboxylase of the invention differs from the corresponding wild-type acetyl-Coenzyme A carboxylase at amino acid position 2027(*Am*). Wild-type *A. myosuroides* acetyl-Coenzyme A carboxylase has a tryptophan at position 2027(*Am*). Acetyl-Coenzyme A carboxylase enzymes of the invention will typically have an amino acid other than tryptophan at this position. Suitable examples of amino acids that may be found at this position in the acetyl-Coenzyme A carboxylase enzymes of the invention include, but are not limited to, cysteine. In one embodiment, an acetyl-Coenzyme A carboxylase enzyme of the invention will have a cysteine at 2027(*Am*).

[0078] In one embodiment, an acetyl-Coenzyme A carboxylase of the invention differs from the corresponding wild-type acetyl-Coenzyme A carboxylase at amino acid position 2041(*Am*). Wild-type *A. myosuroides* acetyl-Coenzyme A carboxylase has an isoleucine at position 2041(*Am*). Acetyl-Coenzyme A carboxylase enzymes of the invention will typically have an amino acid other than isoleucine at this position. Suitable examples of amino acids that may be found at this position in the acetyl-Coenzyme A carboxylase enzymes of the invention include, but are not limited to, asparagine. In one embodiment, an acetyl-Coenzyme A carboxylase enzyme of the invention will have an asparagine at 2041(*Am*).

[0079] In one embodiment, an acetyl-Coenzyme A carboxylase of the invention differs from the corresponding wild-type acetyl-Coenzyme A carboxylase at amino acid position 2078(*Am*). Wild-type *A. myosuroides* acetyl-Coenzyme A carboxylase has an aspartate at position 2078(*Am*). Acetyl-Coenzyme A carboxylase enzymes of the invention will typically have an amino acid other than aspartate at this position. Suitable examples of amino acids that may be found at this position in the acetyl-Coenzyme A carboxylase enzymes of the

invention include, but are not limited to, glycine. In one embodiment, an acetyl-Coenzyme A carboxylase enzyme of the invention will have a glycine at 2078(*Am*).

[0080] In one embodiment, an acetyl-Coenzyme A carboxylase of the invention differs from the corresponding wild-type acetyl-Coenzyme A carboxylase at amino acid position 2088(*Am*). Wild-type *A. myosuroides* acetyl-Coenzyme A carboxylase has a cysteine at position 2088(*Am*). Acetyl-Coenzyme A carboxylase enzymes of the invention will typically have an amino acid other than cysteine at this position. Suitable examples of amino acids that may be found at this position in the acetyl-Coenzyme A carboxylase enzymes of the invention include, but are not limited to, arginine. In one embodiment, an acetyl-Coenzyme A carboxylase enzyme of the invention will have an arginine at 2088(*Am*).

[0081] In one embodiment, an acetyl-Coenzyme A carboxylase of the invention differs from the corresponding wild-type acetyl-Coenzyme A carboxylase at amino acid position 2096(*Am*). Wild-type *A. myosuroides* acetyl-Coenzyme A carboxylase has a glycine at position 2096(*Am*). Acetyl-Coenzyme A carboxylase enzymes of the invention will typically have an amino acid other than glycine at this position. Suitable examples of amino acids that may be found at this position in the acetyl-Coenzyme A carboxylase enzymes of the invention include, but are not limited to, alanine. In one embodiment, an acetyl-Coenzyme A carboxylase enzyme of the invention will have an alanine at 2096(*Am*).

[0082] The present invention also encompasses acetyl-Coenzyme A carboxylase enzymes with an amino acid sequence that differs in more than one amino acid position from that of the acetyl-Coenzyme A carboxylase enzyme found in the corresponding wild-type plant. For example, an acetyl-Coenzyme A carboxylase of the invention may differ in 2, 3, 4, 5, 6, or 7 positions from that of the acetyl-Coenzyme A carboxylase enzyme found in the corresponding wild-type plant.

[0083] In one embodiment, an acetyl-Coenzyme A carboxylase of the invention differs from the corresponding wild-type acetyl-Coenzyme A carboxylase at amino acid position 1781(*Am*) and at one or more additional amino acid positions. Acetyl-Coenzyme A carboxylase enzymes of the invention will typically have a leucine or an alanine at position 1781(*Am*). In addition, enzymes of this embodiment will also comprise one or more of a cysteine at position 1999(*Am*), a cysteine at position 2027(*Am*), an asparagine at position

2041(*Am*), a glycine at position 2078(*Am*), an arginine at position 2088(*Am*), and an alanine at position 2096(*Am*). In one embodiment, an acetyl-Coenzyme A carboxylase of the invention will have a leucine or an alanine at position 1781(*Am*) and a cysteine at position 2027(*Am*). In one embodiment, an acetyl-Coenzyme A carboxylase of the invention will have a leucine or an alanine at position 1781(*Am*) and an asparagine at position 2041(*Am*). In one embodiment, an acetyl-Coenzyme A carboxylase of the invention will have a leucine or an alanine at position 1781(*Am*) and an alanine at position 2096(*Am*). In one embodiment, an acetyl-Coenzyme A carboxylase of the invention will have a leucine or an alanine at position 1781(*Am*), a cysteine at position 2027(*Am*), and an asparagine at position 2041(*Am*). In one embodiment, an acetyl-Coenzyme A carboxylase of the invention will have a leucine or an alanine at position 1781(*Am*), a cysteine at position 2027(*Am*), an asparagine at position 2041(*Am*), and an alanine at position 2096(*Am*).

[0084] In one embodiment, an acetyl-Coenzyme A carboxylase of the invention differs from the corresponding wild-type acetyl-Coenzyme A carboxylase at amino acid position 1999(*Am*) and at one or more additional amino acid positions. Acetyl-Coenzyme A carboxylase enzymes of the invention will typically have a cysteine at position 1999(*Am*). In addition, enzymes of this embodiment will also comprise one or more of a leucine or alanine at position 1781(*Am*), a cysteine at position 2027(*Am*), an asparagine at position 2041(*Am*), a glycine at position 2078(*Am*), an arginine at position 2088(*Am*), and an alanine at position 2096. In one embodiment, an acetyl-Coenzyme A carboxylase of the invention will have a cysteine at position 1999(*Am*) and a leucine or alanine at position 1781(*Am*) and a cysteine at position 2027(*Am*). In one embodiment, an acetyl-Coenzyme A carboxylase of the invention will have a cysteine at position 1999(*Am*) and a leucine or alanine at position 1781(*Am*) and an asparagine at position 2041(*Am*). In one embodiment, an acetyl-Coenzyme A carboxylase of the invention will have a cysteine at position 1999(*Am*) and a leucine or alanine at position 1781(*Am*), a cysteine at position 2027(*Am*), and an asparagine at position 2041(*Am*).

[0085] In one embodiment, an acetyl-Coenzyme A carboxylase of the invention differs from the corresponding wild-type acetyl-Coenzyme A carboxylase at amino acid position 2027(*Am*) and at one or more additional amino acid positions. Acetyl-Coenzyme A carboxylase enzymes of the invention will typically have a cysteine at position 2027(*Am*). In

addition, enzymes of this embodiment will also comprise one or more of a leucine or alanine at position 1781(*Am*), a cysteine at position 1999(*Am*), an asparagine at position 2041(*Am*), a glycine at position 2078(*Am*), an arginine at position 2088(*Am*), and an alanine at position 2096(*Am*). In one embodiment, an acetyl-Coenzyme A carboxylase of the invention will have a cysteine at position 2027(*Am*) and a leucine or an alanine at position 1781(*Am*).

[0086] In one embodiment, an acetyl-Coenzyme A carboxylase of the invention differs from the corresponding wild-type acetyl-Coenzyme A carboxylase at amino acid position 2041(*Am*) and at one or more additional amino acid positions. Acetyl-Coenzyme A carboxylase enzymes of the invention will typically have an isoleucine at position 2041(*Am*). In addition, enzymes of this embodiment will also comprise one or more of a leucine or alanine at position 1781(*Am*), a cysteine at position 1999(*Am*), a cysteine at position 2027(*Am*), a glycine at position 2078(*Am*), an arginine at position 2088(*Am*), and an alanine at position 2096(*Am*). In one embodiment, an acetyl-Coenzyme A carboxylase of the invention will have an asparagine at position 2041(*Am*) and a leucine or alanine at position 1781(*Am*).

[0087] In one embodiment, an acetyl-Coenzyme A carboxylase of the invention differs from the corresponding wild-type acetyl-Coenzyme A carboxylase at amino acid position 2078(*Am*) and at one or more additional amino acid positions. Acetyl-Coenzyme A carboxylase enzymes of the invention will typically have a glycine at position 2078(*Am*). In addition, enzymes of this embodiment will also comprise one or more of a leucine or alanine at position 1781(*Am*), a cysteine at position 1999(*Am*), a cysteine at position 2027(*Am*), an asparagine at position 2041(*Am*), an arginine at position 2088(*Am*), and an alanine at position 2096(*Am*). In one embodiment, an acetyl-Coenzyme A carboxylase of the invention will have a glycine at position 2078(*Am*) and a leucine or alanine at position 1781(*Am*). In one embodiment, an acetyl-Coenzyme A carboxylase of the invention will have a glycine at position 2078(*Am*) and an alanine at position 2096(*Am*).

[0088] In one embodiment, an acetyl-Coenzyme A carboxylase of the invention differs from the corresponding wild-type acetyl-Coenzyme A carboxylase at amino acid position 2088(*Am*) and at one or more additional amino acid positions. Acetyl-Coenzyme A carboxylase enzymes of the invention will typically have an arginine at position 2088(*Am*).

In addition, enzymes of this embodiment will also comprise one or more of a leucine or alanine at position 1781(*Am*), a cysteine at position 1999(*Am*), a cysteine at position 2027(*Am*), an asparagine at position 2041(*Am*), a glycine at position 2078(*Am*), and an alanine at position 2096(*Am*). In one embodiment, an acetyl-Coenzyme A carboxylase of the invention will have an arginine at position 2088(*Am*) and a leucine or alanine at position 1781(*Am*). In one embodiment, an acetyl-Coenzyme A carboxylase of the invention will have an arginine at position 2088(*Am*) and an alanine at position 2096(*Am*).

[0089] In one embodiment, an acetyl-Coenzyme A carboxylase of the invention differs from the corresponding wild-type acetyl-Coenzyme A carboxylase at amino acid position 2096(*Am*) and at one or more additional amino acid positions. Acetyl-Coenzyme A carboxylase enzymes of the invention will typically have an alanine at position 2096(*Am*). In addition, enzymes of this embodiment will also comprise one or more of a leucine or alanine at position 1781(*Am*), a cysteine at position 1999(*Am*), a cysteine at position 2027(*Am*), an asparagine at position 2041(*Am*), a glycine at position 2078(*Am*), and an arginine at position 2088(*Am*). In one embodiment, an acetyl-Coenzyme A carboxylase of the invention will have an alanine at position 2096(*Am*) and a leucine or alanine at position 1781(*Am*). In one embodiment, an acetyl-Coenzyme A carboxylase of the invention will have an alanine at position 2096(*Am*) and an alanine at position 2096(*Am*).

[0090] Nucleic acid molecules

[0091] The present invention also encompasses nucleic acid molecules that encode all or a portion of the acetyl-Coenzyme A carboxylase enzymes described above. Nucleic acid molecules of the invention may comprise a nucleic acid sequence encoding an amino acid sequence comprising a modified version of one or both of SEQ ID NOs: 2 and 3, wherein the sequence is modified such that the encoded protein comprises one or more of the following: the amino acid at position 1,781(*Am*) is leucine or alanine; the amino acid at position 1,999(*Am*) is cysteine; the amino acid at position 2,027(*Am*) is cysteine; the amino acid at position 2,041(*Am*) is asparagine; the amino acid at position 2,078(*Am*) is glycine; the amino acid at position 2088(*Am*) is arginine or the amino acid at position 2,096(*Am*) is alanine, as well as nucleic acid molecules complementary to all or a portion of the coding sequences. In some embodiments, a nucleic acid molecule of the invention may encode an acetyl-

Coenzyme A carboxylase having multiple differences from the wild type acetyl-Coenzyme A carboxylase as described above.

[0092] In one embodiment, a nucleic acid molecule of the invention may encode an acetyl-Coenzyme A carboxylase comprising a leucine or an alanine at position 1781(*Am*) and a cysteine at position 2027(*Am*). In one embodiment, a nucleic acid molecule of the invention may encode an acetyl-Coenzyme A carboxylase comprising a leucine or an alanine at position 1781(*Am*) and an asparagine at position 2041(*Am*). In one embodiment, a nucleic acid molecule of the invention may encode an acetyl-Coenzyme A carboxylase comprising a leucine or an alanine at position 1781(*Am*) and an alanine at position 2096(*Am*). In one embodiment, a nucleic acid molecule of the invention may encode an acetyl-Coenzyme A carboxylase comprising a leucine or an alanine at position 1781(*Am*), a cysteine at position 2027(*Am*), and an asparagine at position 2041(*Am*). In one embodiment, a nucleic acid molecule of the invention may encode an acetyl-Coenzyme A carboxylase comprising a leucine or an alanine at position 1781(*Am*), a cysteine at position 2027(*Am*), an asparagine at position 2041(*Am*), and an alanine at position 2096(*Am*).

[0093] A nucleic acid molecule of the invention may be DNA, derived from genomic DNA or cDNA, or RNA. A nucleic acid molecule of the invention may be naturally occurring or may be synthetic. A nucleic acid molecule of the invention may be isolated, recombinant and/or mutagenized.

[0094] In one embodiment, a nucleic acid molecule of the invention encodes an acetyl-Coenzyme A carboxylase enzyme in which the amino acid at 1781(*Am*) is leucine or alanine or is complementary to such a nucleic acid molecule. Such nucleic acid molecules include, but are not limited to, genomic DNA that serves as a template for a primary RNA transcription, a plasmid molecule encoding the acetyl-Coenzyme A carboxylase, as well as an mRNA encoding such an acetyl-Coenzyme A carboxylase.

[0095] Nucleic acid molecules of the invention may comprise non-coding sequences, which may or may not be transcribed. Non-coding sequences that may be included in the nucleic acid molecules of the invention include, but are not limited to, 5' and 3' UTRs, polyadenylation signals and regulatory sequences that control gene expression (e.g., promoters). Nucleic acid molecules of the invention may also comprise sequences encoding

transit peptides, protease cleavage sites, covalent modification sites and the like. In one embodiment, nucleic acid molecules of the invention encode a chloroplast transit peptide sequence in addition to a sequence encoding an acetyl-Coenzyme A carboxylase enzyme.

[0096] In another embodiment, nucleic acid molecules of the invention may encode an acetyl-Coenzyme A carboxylase enzyme having at least 50%, 60%, 70%, 75%, 80%, 85%, 90%, 95% or more sequence identity to a modified version of one or both of SEQ ID NOs: 2 and 3, wherein the sequence is modified such that the encoded protein comprises one or more of the following: the amino acid at position 1,781(*Am*) is leucine or alanine; the amino acid at position 1,999(*Am*) is cysteine; the amino acid at position 2,027(*Am*) is cysteine; the amino acid at position 2,041(*Am*) is asparagine; the amino acid at position 2,078(*Am*) is glycine; the amino acid at position 2088(*Am*) is arginine or the amino acid at position 2,096(*Am*) is alanine, as well as nucleic acid molecules complementary to all or a portion of the coding sequences.

[0097] As used herein, "percent (%) sequence identity" is defined as the percentage of nucleotides or amino acids in the candidate derivative sequence identical with the nucleotides or amino acids in the subject sequence (or specified portion thereof), after aligning the sequences and introducing gaps, if necessary to achieve the maximum percent sequence identity, as generated by the program BLAST available at <http://blast.ncbi.nlm.nih.gov/Blast.cgi> with search parameters set to default values.

[0098] The present invention also encompasses nucleic acid molecules that hybridize to nucleic acid molecules encoding acetyl-Coenzyme A carboxylase of the invention as well as nucleic acid molecules that hybridize to the reverse complement of nucleic acid molecules encoding an acetyl-Coenzyme A carboxylase of the invention. In one embodiment, nucleic acid molecules of the invention comprise nucleic acid molecules that hybridize to a nucleic acid molecule encoding one or more of a modified version of one or both of SEQ ID NOs: 2 and 3, wherein the sequence is modified such that the encoded protein comprises one or more of the following: the amino acid at position 1,781(*Am*) is leucine or alanine; the amino acid at position 1,999(*Am*) is cysteine; the amino acid at position 2,027(*Am*) is cysteine; the amino acid at position 2,041(*Am*) is asparagine; the amino acid at position 2,078(*Am*) is glycine; the amino acid at position 2088(*Am*) is arginine or the amino acid at position 2,096(*Am*) is

alanine, as well as nucleic acid molecules complementary to all or a portion of the coding sequences, or the reverse complement of such nucleic acid molecules under stringent conditions. The stringency of hybridization can be controlled by temperature, ionic strength, pH, and the presence of denaturing agents such as formamide during hybridization and washing. Stringent conditions that may be used include those defined in *Current Protocols in Molecular Biology*, Vol. 1, Chap. 2.10, John Wiley & Sons, Publishers (1994) and Sambrook et al., *Molecular Cloning*, Cold Spring Harbor (1989) which are specifically incorporated herein as they relate to teaching stringent conditions.

[0099] In one embodiment, nucleic acid molecules invention encompasses oligonucleotides that may be used as hybridization probes, sequencing primers, and/or PCR primers. Such oligonucleotides may be used, for example, to determine a codon sequence at a particular position in a nucleic acid molecule encoding an acetyl-Coenzyme A carboxylase, for example, by allele specific PCR. Such oligonucleotides may be from about 15 to about 30, from about 20 to about 30, or from about 20-25 nucleotides in length.

[0100] Herbicides

[0101] The present invention provides plants, e.g., rice plants, that are tolerant of concentrations of herbicide that normally inhibit the growth of wild-type plants. The plants are typically resistant to herbicides that interfere with acetyl-Coenzyme A carboxylase activity. Any herbicide that inhibits acetyl-Coenzyme A carboxylase activity can be used in conjunction with the plants of the invention. Suitable examples include, but are not limited to, cyclohexanedione herbicides, aryloxyphenoxy propionate herbicides, and phenylpyrazole herbicides. In some methods of controlling weeds and/or growing herbicide-tolerant plants, at least one herbicide is selected from the group consisting of sethoxydim, cycloxydim, tepraloxym, haloxyfop, or a derivative of any of these herbicides.

[0102] Table 4 provides a list of cyclohexanedione herbicides (DIMs, also referred to as: cyclohexene oxime cyclohexanedione oxime; and CHD) that interfere with acetyl-Coenzyme A carboxylase activity and may be used in conjunction with the herbicide-tolerant plants of the invention. One skilled in the art will recognize that other herbicides in this class exist and may be used in conjunction with the herbicide-tolerant plants of the invention.

[0103] Table 4

Active Name	Synonyms	Example Products
Alloxydim	Carbodimedon, Zizalon, BAS 90210H	
Butroxydim	Butoxydim	Falcon
Caloxydim		
Clethodim	Cletodime	Select; Prism; Centurion
Cloproxydim		
Cycloxydim	BAS 517H, BAS 517	Focus
Profoxydim	Clefoxydim, BAS 625H, BAS 625	Aura
Sethoxydim	Cyethoxydim, BAS 562H, BASF 620	Poast; Rezult; Vantage
Tepraloxym	BAS 620H, BAS 620	Aramo
Tralkoxydim	Tralkoxydime; Tralkoxidym	Achieve; Splendor

[0104] Table 5 presents a list of aryloxyphenoxy propionate herbicides (also referred to as aryloxyphenoxy propanoate; aryloxyphenoxyalkanoate; oxyphenoxy; APP; AOPP; APA; APPA; FOP, note that these are sometime written with the suffix ‘-oic’) that interfere with acetyl-Coenzyme A carboxylase activity and may be used in conjunction with the herbicide-tolerant plants of the invention. One skilled in the art will recognize that other herbicides in this class exist and may be used in conjunction with the herbicide-tolerant plants of the invention.

[0105] Table 5

Active Name	Synonyms	Example Products
Chlorazifop		
Clodinafop		Discover, Topik
Clofop	Fenofibric Acid	Alopex
Cyhalofop		Barnstorm; Clincher
Diclofop	Dichlorfop; Illoxan	Hoelon; Hoegrass
Fenoxaprop	Fenoxaprop-P	Option; Fusion; Acclaim
Fenthiaprop		Taifun; Joker
Fluazifop	Fluazifop-P	Fusilade DX; Fusion
Haloxifop	Haloxifop-P	Motsa; Verdict; Gallant
Isoxapyrifop		
Metamifop		
Propaquizafop		Correct; Shogun
Quizalofop	Quizalofop-P; Quizafop	Assure; Targa
Trifop		

- [0106] In addition to the herbicides listed above, any other herbicide that interferes with acetyl-Coenzyme A carboxylase activity may be used in conjunction with the herbicide-tolerant plants of the invention. One example is phenylpyrazoline (also known as DEN; and sometimes referred to under the more general class of Phenylpyrazole). An example of such an herbicide is pinoxaden and it is sold under the tradename Axial.
- [0107] Those skilled in the art will recognize that any derivative of the above mentioned herbicides that inhibits acetyl-Coenzyme A carboxylase activity can be used in the practice of the invention.
- [0108] In addition, any of the above acetyl-Coenzyme A carboxylase-inhibiting herbicides can be combined with one or more herbicides of another class, for example, any of the acetohydroxyacid synthase-inhibiting herbicides, EPSP synthase-inhibiting herbicides, glutamine synthase-inhibiting herbicides, lipid- or pigment-biosynthesis inhibitor herbicides, cell-membrane disruptor herbicides, photosynthesis or respiration inhibitor herbicides, or growth regulator or growth inhibitor herbicides known in the art. Non-limiting examples include those recited in Weed Science Society of America's *Herbicide Handbook*, 9th Edition edited by S.A. Senseman, copy right 2007. An herbicidal composition herein can contain one or more agricultural active ingredient(s) selected from the agriculturally-acceptable fungicides, insecticides (including nematicides), miticides, and molluscicides. Non-limiting examples include those recited in 2009 Crop Protection Reference (www.greenbook.net), Vance Publications.
- [0109] The herbicide compositions containing such active ingredient(s) can be provided in any of the various formulations known useful in the art. Examples, include suspensions, emulsions, granules, dusts, solutions, and the like.
- [0110] Methods of controlling weeds
- [0111] Herbicide-tolerant plants of the invention may be used in conjunction with an herbicide to which they are tolerant. Herbicides may be applied to the plants of the invention using any techniques known to those skilled in the art. Herbicides may be applied at any point in the plant cultivation process. For example, herbicides may be applied pre-planting, at planting, pre-emergence, post-emergence or combinations thereof.

- [0112] Herbicide compositions hereof can be applied, e.g., as foliar treatments, soil treatments, seed treatments, or soil drenches. Application can be made, e.g., by spraying, dusting, broadcasting, or any other mode known useful in the art.
- [0113] In one embodiment, herbicides may be used to control the growth of weeds that may be found growing in the vicinity of the herbicide-tolerant plants invention. In embodiments of this type, an herbicide may be applied to a plot in which herbicide-tolerant plants of the invention are growing in vicinity to weeds. An herbicide to which the herbicide-tolerant plant of the invention is tolerant may then be applied to the plot at a concentration sufficient to kill or inhibit the growth of the weed. Concentrations of herbicide sufficient to kill or inhibit the growth of weeds are known in the art.
- [0114] It will be readily apparent to one of ordinary skill in the relevant arts that other suitable modifications and adaptations to the methods and applications described herein are obvious and may be made without departing from the scope of the invention or any embodiment thereof. Having now described the present invention in detail, the same will be more clearly understood by reference to the following examples, which are included herewith for purposes of illustration only and are not intended to be limiting of the invention.

EXAMPLES

EXAMPLE 1

- [0115] Tissue culture conditions
- [0116] An *in vitro* tissue culture mutagenesis assay has been developed to isolate and characterize plant tissue (e.g., rice tissue) that is tolerant to acetyl-Coenzyme A carboxylase inhibiting herbicides, e.g., tepraloxym, cycloxydim, and sethoxydim. The assay utilizes the somaclonal variation that is found in *in vitro* tissue culture. Spontaneous mutations derived from somaclonal variation can be enhanced by chemical mutagenesis and subsequent selection in a stepwise manner, on increasing concentrations of herbicide.
- [0117] The present invention provides tissue culture conditions for encouraging growth of friable, embryogenic rice callus that is regenerable. Calli were initiated from 4 different rice cultivars encompassing both Japonica (Taipei 309, Nipponbare, Koshihikari) and Indica

(Indica 1) varieties. Dehusked seed were surface sterilized in 70% ethanol for approximately 1 min followed by 20% commercial Clorox bleach for 20 minutes. Seeds were rinsed with sterile water and plated on callus induction media. Various callus induction media were tested. The ingredient lists for the media tested are presented in Table 6.

[0118] Table 6

Ingredient	Supplier	R001M	R025M	R026M	R327M	R008M	MS711R
B5 Vitamins	Sigma					1.0 X	
MS salts	Sigma			1.0 X	1.0 X	1.0 X	1.0 X
MS Vitamins	Sigma			1.0 X	1.0 X		
N6 salts	Phytotech	4.0 g/L	4.0g/L				
N6 vitamins	Phytotech	1.0 X	1.0 X				
L-Proline	Sigma	2.9 g/L	0.5 g/L				1.2 g/L
Casamino Acids	BD	0.3 g/L	0.3 g/L	2 g/L			
Casein Hydrolysate	Sigma						1.0 g/L
L-Asp Monohydrate	Phytotech						150 mg/L
Nicotinic Acid	Sigma						0.5 mg/L
Pyridoxine HCl	Sigma						0.5 mg/L
Thiamine HCl	Sigma						1.0 mg/L
Myo-inositol	Sigma						100 mg/L
MES	Sigma	500 mg/L	500 mg/L	500 mg/L	500 mg/L	500 mg/L	500 mg/L
Maltose	VWR	30 g/L	30 g/L	30 g/L	30 g/L		
Sorbitol	Duchefa			30 g/L			
Sucrose	VWR					10 g/L	30 g/L
NAA	Duchefa					50 µg/L	
2,4-D	Sigma	2.0 mg/L					1.0 mg/L
MgCl ₂ ·6H ₂ O	VWR					750 mg/L	
→pH		5.8	5.8	5.8	5.8	5.8	5.7
Gelrite	Duchefa	4.0 g/L				2.5 g/L	
Agarose Type1	Sigma		7.0 g/L	10 g/L	10 g/L		
→Autoclave		15 min	15 min	15 min	15 min	15 min	20 min
Kinetin	Sigma		2.0 mg/L	2.0 mg/L			
NAA	Duchefa		1.0 mg/L	1.0 mg/L			
ABA	Sigma		5.0 mg/L				
Cefotaxime	Duchefa		0.1 g/L	0.1 g/L	0.1 g/L		
Vancomycin	Duchefa		0.1 g/L	0.1 g/L	0.1 g/L		
G418 Disulfate	Sigma		20 mg/L	20 mg/L	20 mg/L		

[0119] R001M callus induction media was selected after testing numerous variations. Cultures were kept in the dark at 30°C. Embryogenic callus was subcultured to fresh media after 10-14 days.

EXAMPLE 2

[0120] Selection of herbicide-tolerant calli

[0121] Once tissue culture conditions were determined, further establishment of selection conditions were established through the analysis of tissue survival in kill curves with cycloxydim, tepraloxym, sethoxydim (Figure 1) or haloxyfop (not shown). Careful consideration of accumulation of the herbicide in the tissue, as well as its persistence and

stability in the cells and the culture media was performed. Through these experiments, a sub-lethal dose has been established for the initial selection of mutated material.

[0122] After the establishment of the starting dose of sethoxydim, cycloxydim, tepraloxym, and haloxyfop in selection media, the tissues were selected in a step-wise fashion by increasing the concentration of the ACCase inhibitor with each transfer until cells are recovered that grew vigorously in the presence of toxic doses (see Figure 2). The resulting calli were further subcultured every 3-4 weeks to R001M with selective agent. Over 26,000 calli were subjected to selection for 4-5 subcultures until the selective pressure was above toxic levels as determined by kill curves and observations of continued culture. Toxic levels were determined to be 50 μ M sethoxydim, 20 μ M cycloxydim, 2.5 μ M tepraloxym (Figure 1) and 10 μ M haloxyfop (not shown).

[0123] Alternatively, liquid cultures initiated from calli in MS711R (Table 5) with slow shaking and weekly subcultures. Once liquid cultures were established, selection agent was added directly to the flask at each subculture. Following 2-4 rounds of liquid selection, cultures were transferred to filters on solid R001M media for further growth.

EXAMPLE 3

[0124] Regeneration of plants

[0125] Tolerant tissue was regenerated and characterized molecularly for ACCase gene sequence mutations and/or biochemically for altered ACCase activity in the presence of the selective agent.

[0126] Following herbicide selection, calli were regenerated using a media regime of R025M for 10 – 14 days, R026M for ca. 2 weeks, R327M until well formed shoots were developed, and R008S until shoots were well rooted for transfer to the greenhouse (Table 5). Regeneration was carried out in the light. No selection agent was included during regeneration.

[0127] Once strong roots were established, M0 regenerants were transplant to the greenhouse in 4" square pots in a mixture of sand, NC Sandhills loamy soil, and Redi-earth (2:4:6) supplemented with gypsum. Transplants were maintained under a clear plastic cup until they were adapted to greenhouse conditions (ca. 1 week). The greenhouse was set to a

day/night cycle of 27°C/21°C (80°F/70°F) with 600W high pressure sodium lights supplementing light to maintain a 14 hour day length. Plants were watered 2-3 times a day depending in the weather and fertilized daily. Rice plants selected for seed increase were transplanted into one gallon pots. As plants approached maturity and prepared to bolt, the pots were placed in small flood flats to better maintain water and nutrient delivery. Plants were monitored for insects and plant health and managed under standard Integrated Pest Management practices.

EXAMPLE 4

[0128] Sequence analysis

[0129] Leaf tissue was collected from clonal plants separated for transplanting and analyzed as individuals. Genomic DNA was extracted using a Wizard® 96 Magnetic DNA Plant System kit (Promega, US Patent Nos. 6,027,945 & 6,368,800) as directed by the manufacturer. Isolated DNA was PCR amplified using one forward and one reverse primer.

[0130] Forward Primers:

[0131] OsACCpU5142: 5'-GCAAATGATATTACGTTTCAGAGCTG-3' (SEQ ID NO:7)

[0132] OsACCpU5205: 5'-GTTACCAACCTAGCCTGTGAGAAG-3' (SEQ ID NO: 8)

[0133] Reverse Primers:

[0134] OsACCpL7100: 5'-GATTTCTTCAACAAGTTGAGCTCTTC-3' (SEQ ID NO: 9)

[0135] OsACCpL7054: 5'-AGTAACATGGAAAGACCCTGTGGC-3' (SEQ ID NO: 10)

[0136] PCR amplification was performed using Hotstar Taq DNA Polymerase (Qiagen) using touchdown thermocycling program as follows: 96°C for 15 min, followed by 35 cycles (96°C, 30 sec; 58°C – 0.2 °C per cycle, 30 sec; 72°C, 3 min and 30 sec), 10 min at 72°C.

[0137] PCR products were verified for concentration and fragment size via agarose gel electrophoresis. Dephosphorylated PCR products were analyzed by direct sequence using the PCR primers (DNA Landmarks). Chromatogram trace files (.scf) were analyzed for mutation relative to Os05g0295300 using Vector NTI Advance 10™ (Invitrogen). Based on

sequence information, two mutations were identified in several individuals. I1781L and D2078G were present in the heterozygous state. Sequence analysis was performed on the representative chromatograms and corresponding AlignX alignment with default settings and edited to call secondary peaks.

[0138] Samples inconsistent with an ACCase mutation were spray tested for tolerance and discarded as escapes. Surprisingly, most of the recovered lines were heterozygous for the I1781L mutation and resistant events were generated in all tested genotypes using cycloxydim or sethoxydim: Indica1 (≥ 18 lines), Taipei 309 (≥ 14 lines), Nipponbare (≥ 3 lines), and Koshihikare (≥ 6 lines). One line was heterozygous for a D2078G mutation. The D2078G heterozygote line appeared stunted with narrow leaves, while the I1781L heterozygotes varied in appearance, but most looked normal relative to their parental genotype. Several escapes were recovered and confirmed by sequencing and spray testing; however, sequencing results of the herbicide sensitive region of ACCase revealed that most tolerant mutants were heterozygous for an I1781L, A to T mutation. One line, ARWI010, was heterozygous for a D2078G, A to G mutation. To date, all recovered plants lacking an ACCase mutation have been sensitive to herbicide application in the greenhouse.

EXAMPLE 5

[0139] Demonstration of herbicide-tolerance

[0140] Selected mutants and escapes were transferred to small pots. Wild-type cultivars and 3 biovars of red rice were germinated from seed to serve as controls.

[0141] After ca. 3 weeks post-transplant, M0 regenerants were sprayed using a track sprayer with 400-1600 g ai/ha cycloxydim (BAS 517H) supplemented with 0.1% methylated seed oil. After the plants had adapted to greenhouse conditions, a subset were sprayed with 800 g ai/ha cycloxydim. Once sprayed, plants were kept on drought conditions for 24 hours before being watered and fertilized again. Sprayed plants were photographed and rated for herbicide injury at 1 (Figure 3) and 2 weeks after treatment (Figure 4). No injury was observed on plants containing the I1781L heterozygous mutation while control plants and tissue culture escapes (regenerated plants negative for the sequenced mutations) were heavily

damaged after treatment (Figures 3 & 4). Figures 5-16 provide nucleic acid and/or amino acid sequences of acetyl-Coenzyme A carboxylase enzymes from various plants.

[0142] While the foregoing invention has been described in some detail for purposes of clarity and understanding, it will be appreciated by one skilled in the art from a reading of this disclosure that various changes in form and detail can be made without departing from the true scope of the invention and appended claims. All patents and publications cited herein are entirely incorporated herein by reference.

What is claimed is:

1. A rice plant tolerant to at least one herbicide that inhibits acetyl-Coenzyme A carboxylase activity at levels of herbicide that would normally inhibit the growth of a rice plant.
2. A rice plant that expresses an acetyl-Coenzyme A carboxylase (ACCCase) in which the amino acid sequence differs from an amino acid sequence of an acetyl-Coenzyme A carboxylase of a wild-type rice plant at one or more of the following positions: 1,781(*Am*), 1,999(*Am*), 2,027(*Am*), 2,041(*Am*), 2,078(*Am*), 2088(*Am*) or 2,096(*Am*).
3. A rice plant, wherein said plant expresses an acetyl-Coenzyme A carboxylase (ACCCase) in which the amino acid sequence comprises one or more of the following: the amino acid at position 1,781(*Am*) is other than isoleucine; the amino acid at position 1,999(*Am*) is other than tryptophan; the amino acid at position 2,027(*Am*) is other than tryptophan; the amino acid at position 2,041(*Am*) is other than isoleucine; the amino acid at position 2,078(*Am*) is other than aspartate; the amino acid at position 2088(*Am*) is other than cysteine; or the amino acid at position 2,096(*Am*) is other than glycine.
4. A rice plant, wherein said plant expresses an acetyl-Coenzyme A carboxylase (ACCCase) in which the amino acid sequence comprises one or more of the following: the amino acid at position 1,781(*Am*) is leucine or alanine; the amino acid at position 1,999(*Am*) is cysteine; the amino acid at position 2,027(*Am*) is cysteine; the amino acid at position 2,041(*Am*) is asparagine; the amino acid at position 2,078(*Am*) is glycine; the amino acid at position 2088(*Am*) is Arginine or the amino acid at position 2,096(*Am*) is alanine.
5. An herbicide-tolerant rice plant which is tolerant to at least one herbicide that inhibits acetyl-Coenzyme A carboxylase activity at levels of herbicide that would normally inhibit the growth of said plant, wherein the herbicide-tolerant plant is produced by:
 - a) obtaining cells from a plant that is not tolerant to the herbicide;
 - b) contacting the cells with a medium comprising one or more acetyl-Coenzyme A carboxylase inhibitors; and
 - c) generating an herbicide-tolerant plant from the cells;wherein the herbicide-tolerant plant was generated by performing a), b) and c) or is a progeny of a plant generated by performing a), b), and c).

6. A rice plant, wherein one or more of the genomes of said rice plant encode a protein comprising an amino acid sequence comprising one or more of a modified SEQ ID NO:2 and a modified SEQ ID NO:3, wherein the sequence is modified such that the encoded protein comprises one or more of the following: the amino acid at position 1,781(*Am*) is leucine or alanine; the amino acid at position 1,999(*Am*) is cysteine; the amino acid at position 2,027(*Am*) is cysteine; the amino acid at position 2,041(*Am*) is asparagine; the amino acid at position 2,078(*Am*) is glycine; the amino acid at position 2088(*Am*) is arginine or the amino acid at position 2,096(*Am*) is alanine.

7. A rice plant wherein:

(a) growth of said plant is tolerant to acetyl-Coenzyme A carboxylase-inhibiting herbicides at levels of herbicide that would normally inhibit the growth of a rice plant;

(b) said plant is grown from a seed having ATCC accession number PTA-10267; or is a mutant, recombinant, or genetically engineered derivative of the plant grown from a seed having ATCC accession number PTA-10267 or of any progeny of the plant grown from a seed having ATCC accession number PTA-10267; or is a plant which is the progeny of any of these plants; and

(c) said plant has the herbicide tolerance characteristics of the plant grown from a seed having ATCC accession number PTA-10267.

8. An herbicide-tolerant rice plant according to claim 5, wherein the cells are in the form of a callus.

9. A plant of any one of claims claim 1, 2, 3, 4, 5, 6, or 7, wherein said plant is a member of the species *O. sativa*.

10. A rice plant according to any one of claims 1, 2, 3, 4, 5, 6, or 7, wherein growth of the plant is tolerant to aryloxyphenoxypropionate herbicides, cyclohexanedione herbicides, phenylpyrazoline herbicides or combinations thereof at levels of herbicide that would normally inhibit the growth of a rice plant.

11. A rice plant according to any one of claims 1, 2, 3, 4, 5, 6, or 7, wherein growth of the plant is tolerant to at least one herbicide is selected from the group consisting of alloxymid, butoxydim, caloxydim, clethodim, cloproxydim, cycloxydim, sethoxydim, tepraloxymid, tralkoxydim, chlorazifop, clodinafop, clofop, diclofop, fenoxaprop, fenthiaprop, fluazifop,

haloxyfop, isoxapyrifop, propaquizafop, quizalofop, trifop, and pinoxaden or a derivative of any of these herbicides at levels of herbicide that would normally inhibit the growth of a rice plant.

12. A rice plant according to any one of claims 1, 2, 3, 4, 5, 6, or 7, wherein growth of the plant is tolerant to an amount of one or more of sethoxydim, cycloxydim, tepraloxym, haloxyfop, or a derivative of any of these herbicides at levels of herbicide that would normally inhibit the growth of a rice plant.

13. A rice plant according to any one of claims 1, 2, 3, 4, 5, 6, or 7, wherein said rice plant is not a GMO-plant.

14. A rice plant according to any one of claims 1, 2, 3, 4, 5, 6, or 7, wherein said rice plant is a mutagenized rice plant.

15. A cell from a rice plant according to any one of claims 1, 2, 3, 4, 5, 6, or 7.

16. A method for controlling growth of weeds in vicinity to rice plants, comprising: applying to the weeds and rice plants an amount of an acetyl-Coenzyme A carboxylase-inhibiting herbicide that inhibits naturally occurring acetyl-Coenzyme A carboxylase activity, wherein said rice plants comprise altered acetyl-Coenzyme A carboxylase activity such that said rice plants are tolerant to the applied amount of herbicide.

17. The method of claim 16, wherein said acetyl-Coenzyme A carboxylase-inhibiting herbicide is selected from the group consisting of aryloxyphenoxypropionate herbicides, cyclohexanedione herbicides, phenylpyrazoline herbicides or combinations thereof.

18. The method according to claim 16, wherein at least one herbicide is selected from the group consisting of alloxydim, butoxydim, caloxydim, clethodim, cloproxydim, cycloxydim, sethoxydim, tepraloxym, tralkoxydim, chlorazifop, clodinafop, clofop, diclofop, fenoxaprop, fenthiaprop, fluazifop, haloxyfop, isoxapyrifop, propaquizafop, quizalofop, trifop, and pinoxaden or a derivative of any of these herbicides.

19. The method according to claim 16, wherein at least one herbicide is selected from the group consisting of sethoxydim, cycloxydim, tepraloxym, haloxyfop, or a derivative of any of these herbicides that would normally inhibit the growth of a rice plant.

20. A method for controlling growth of weeds in vicinity to rice plants, comprising:

applying one or more herbicides to the weeds and to the rice plants at levels of herbicide that would normally inhibit the growth of a rice plant, wherein at least one herbicide inhibits acetyl-Coenzyme A carboxylase activity.

21. A method according to claim 20, wherein at least one herbicide is selected from the group consisting of aryloxyphenoxypropionate herbicides, cyclohexanedione herbicides, phenylpyrazoline herbicides or combinations thereof.

22. A method according to claim 20, wherein at least one herbicide is selected from the group consisting of alloxydim, butroxydim, caloxydim, clethodim, cloproxydim, cycloxydim, sethoxydim, tepraloxym, tralkoxydim, chlorazifop, clodinafop, clofop, diclofop, fenoxaprop, fenthiaprop, fluazifop, haloxyfop, isoxapyrifop, propaquizafop, quizalofop, trifop, and pinoxaden, or a derivative of any of these herbicides.

23. A method according to claim 20, wherein at least one herbicide is selected from the group consisting of sethoxydim, cycloxydim, tepraloxym, haloxyfop, or a derivative of any of these herbicides.

24. A method for controlling growth of weeds, comprising:

(a) crossing an herbicide-tolerant rice plant with other rice germplasm, and harvesting the resulting hybrid rice seed;

(b) planting the hybrid rice seed; and

(c) applying one or more acetyl-Coenzyme A carboxylase-inhibiting herbicides to the hybrid rice and to the weeds in vicinity to the hybrid rice at levels of herbicide that would normally inhibit the growth of a rice plant.

25. A method according to claim 24, wherein at least one herbicide is selected from the group consisting of aryloxyphenoxypropionate herbicides, cyclohexanedione herbicides, phenylpyrazoline herbicides or combinations thereof.

26. A method according to claim 24, wherein at least one herbicide is selected from the group consisting of alloxydim, butroxydim, caloxydim, clethodim, cloproxydim, cycloxydim, sethoxydim, tepraloxym, tralkoxydim, chlorazifop, clodinafop, clofop, diclofop, fenoxaprop, fenthiaprop, fluazifop, haloxyfop, isoxapyrifop, propaquizafop, quizalofop, trifop, and pinoxaden, or a derivative of any of these herbicides.

27. A method according to claim 24, wherein at least one herbicide is selected from the group consisting of sethoxydim, cycloxydim, tepraloxym, haloxyfop, or a derivative of any of these herbicides.

28. A method for selecting herbicide-tolerant rice plants, comprising:

(a) crossing an herbicide-tolerant rice plant with other rice germplasm, and harvesting the resulting hybrid rice seed;

(b) planting the hybrid rice seed;

(c) applying one or more herbicides to the hybrid rice at levels of herbicide that would normally inhibit the growth of a rice plant, wherein at least one of the herbicides inhibits acetyl-Coenzyme A carboxylase; and

(d) harvesting seeds from the rice plants to which herbicide has been applied.

29. A method according to claim 28, wherein at least one herbicide is selected from the group consisting of aryloxyphenoxypropionate herbicides, cyclohexanedione herbicides, phenylpyrazoline herbicides or combinations thereof.

30. A method according to claim 28, wherein at least one herbicide is selected from the group consisting of alloxym, butroxydim, caloxydim, clethodim, cloproxydim, cycloxydim, sethoxydim, tepraloxym, tralkoxydim, chlorazifop, clodinafop, clofop, diclofop, fenoxaprop, fenthiaprop, fluazifop, haloxyfop, isoxapyrifop, propaquizafop, quizalofop, trifop, and pinoxaden, or a derivative of any of these herbicides.

31. A method according to claim 28, wherein at least one herbicide is selected from the group consisting of sethoxydim, cycloxydim, tepraloxym, haloxyfop, or a derivative of any of these herbicides.

32. A method for growing herbicide-tolerant rice plants, comprising:

(a) planting rice seeds;

(b) allowing the rice seeds to sprout;

(c) applying one or more herbicides to the rice sprouts at levels of herbicide that would normally inhibit the growth of a rice plant, wherein at least one of the herbicides inhibits acetyl-Coenzyme A carboxylase.

33. A method according to claim 32, wherein at least one herbicide is selected from the group consisting of aryloxyphenoxypropionate herbicides, cyclohexanedione herbicides, phenylpyrazoline herbicides or combinations thereof.

34. A method according to claim 32, wherein at least one herbicide is selected from the group consisting of alloxymid, butroxydim, caloxydim, clethodim, cloproxydim, cycloxydim, sethoxydim, tepraloxymid, tralkoxydim, chlorazifop, clodinafop, clofop, diclofop, fenoxaprop, fenthiaprop, fluazifop, haloxyfop, isoxapyrifop, propaquizafop, quizalofop, trifop, and pinoxaden, or a derivative of any of these herbicides.

35. A method according to claim 32, wherein at least one herbicide is selected from the group consisting of sethoxydim, cycloxydim, tepraloxymid, haloxyfop, or a derivative of any of these herbicides.

36. A method for selecting herbicide-tolerant plants ...

37. A seed of rice cultivar **Indica1**, wherein a representative sample of seed of said cultivar was deposited under ATCC Accession No. PTA-10267.

38. A rice plant, or a part thereof, produced by growing the seed of claim 37.

39. A tissue culture of cells produced from the seed of claim 37.

40. A tissue culture of cells produced from the plant of claim 38, wherein said cells of the tissue culture are produced from a plant part selected from the group consisting of leaves, pollen, embryos, cotyledons, hypocotyls, meristematic cells, roots, root tips, pistils, anthers, flowers and stems.

41. A rice plant generated from the tissue culture of any one of claims 39 or 40, wherein the plant has all the morphological and physiological characteristics of cultivar Indica1.

42. A seed of an herbicide-tolerant rice plant, wherein a plant grown from the seed is tolerant to at least one herbicide that inhibits acetyl-Coenzyme A carboxylase activity at levels of herbicide that would normally inhibit the growth of a rice plant.

43. A seed of a rice plant, wherein a plant grown from the seed expresses an acetyl-Coenzyme A carboxylase (ACCase) in which the amino acid sequence differs from an amino acid sequence of an acetyl-Coenzyme A carboxylase of a wild-type rice plant at one or more of

the following positions: 1,781(*Am*), 1,999(*Am*), 2,027(*Am*), 2,041(*Am*), 2,078(*Am*), 2088(*Am*) or 2,096(*Am*).

44. A seed of a rice plant, wherein a plant grown from the seed expresses an acetyl-Coenzyme A carboxylase (ACCase) in which the amino acid sequence comprises one or more of the following: the amino acid at position 1,781(*Am*) is other than isoleucine; the amino acid at position 1,999(*Am*) is other than tryptophan; the amino acid at position 2,027(*Am*) is other than tryptophan; the amino acid at position 2,041(*Am*) is other than isoleucine; the amino acid at position 2,078(*Am*) is other than aspartate; the amino acid at position 2088(*Am*) is other than cysteine; or the amino acid at position 2,096(*Am*) is other than glycine.

45. A seed of a rice plant, wherein a plant grown from the seed expresses an acetyl-Coenzyme A carboxylase (ACCase) in which the amino acid sequence comprises one or more of the following: the amino acid at position 1,781(*Am*) is leucine or alanine; the amino acid at position 1,999(*Am*) is cysteine; the amino acid at position 2,027(*Am*) is cysteine; the amino acid at position 2,041(*Am*) is asparagine; the amino acid at position 2,078(*Am*) is glycine; the amino acid at position 2088(*Am*) is arginine or the amino acid at position 2,096(*Am*) is alanine.

46. A method for producing rice seed, comprising:
crossing an herbicide-tolerant rice plant with other rice germplasm; and
harvesting the resulting hybrid rice seed, wherein the herbicide-tolerant rice plant is tolerant to aryloxyphenoxypropionate herbicides, cyclohexanedione herbicides, phenylpyrazoline herbicides or combinations thereof at levels of herbicide that would normally inhibit the growth of a rice plant.

47. A method for producing an F1 hybrid rice seed, comprising:
crossing an herbicide-tolerant rice plant with a different rice plant; and
harvesting the resultant F1 hybrid rice seed, wherein the herbicide-tolerant rice plant is tolerant to aryloxyphenoxypropionate herbicides, cyclohexanedione herbicides, phenylpyrazoline herbicides or combinations thereof at levels of herbicide that would normally inhibit the growth of a rice plant.

48. A method of producing an herbicide-tolerant rice plant, comprising:
transforming a cell of a rice plant with a transgene, wherein the transgene encodes an acetyl-Coenzyme A carboxylase enzyme that confers tolerance to at least one herbicide is

selected from the group consisting of aryloxyphenoxypropionate herbicides, cyclohexanedione herbicides, phenylpyrazoline herbicides or combinations thereof.

49. A method according to claim 48, wherein the cell is in the form of a callus.

50. A method according to claim 48, wherein at least one herbicide is selected from the group consisting of alloxymid, butoxydim, caloxymid, clethodim, cloproxydim, cycloxydim, sethoxydim, tepraloxymid, tralkoxymid, chlorazifop, clodinafop, clofop, diclofop, fenoxaprop, fenthiaprop, fluazifop, haloxyfop, isoxapyrifop, propaquizafop, quizalofop, trifop, and pinoxaden, or a derivative of any of these herbicides.

51. A method according to claim 48, wherein at least one herbicide is selected from the group consisting of sethoxydim, cycloxydim, tepraloxymid, haloxyfop, or a derivative of any of these herbicides.

52. A method according to claim 48, wherein the transgene comprises a nucleic acid sequence encoding a protein comprising an amino acid sequence comprising one or more of a modified SEQ ID NO:2 and a modified SEQ ID NO:3, wherein the sequence is modified such that the encoded protein comprises one or more of the following: the amino acid at position 1,781(*Am*) is leucine or alanine; the amino acid at position 1,999(*Am*) is cysteine; the amino acid at position 2,027(*Am*) is cysteine; the amino acid at position 2,041(*Am*) is asparagine; the amino acid at position 2,078(*Am*) is glycine; the amino acid at position 2088(*Am*) is arginine or the amino acid at position 2,096(*Am*) is alanine.

53. An herbicide-tolerant rice plant produced by the method of claim 48.

54. A method of producing an herbicide-tolerant rice plant, comprising:
transforming a cell of a rice plant with a transgene encoding an enzyme that confers herbicide tolerance,

wherein the cell was produced from a rice plant expressing an acetyl-Coenzyme A carboxylase enzyme that confers tolerance to at least one herbicide is selected from the group consisting of aryloxyphenoxypropionate herbicides, cyclohexanedione herbicides, phenylpyrazoline herbicides or combinations thereof.

55. A method according to claim 54, wherein the cell is in the form of a callus.

56. An herbicide-tolerant rice plant produced by the method of claim 54.

57. A method of producing a recombinant rice plant, comprising:
transforming a cell of a rice plant with a transgene,
wherein the cell was produced from a rice plant expressing an acetyl-Coenzyme A
carboxylase enzyme that confers tolerance to at least one herbicide is selected from the group
consisting of aryloxyphenoxypropionate herbicides, cyclohexanedione herbicides,
phenylpyrazoline herbicides or combinations thereof.
58. A method according to claim 57, wherein the cell is in the form of a callus.
59. The method according to claim 57, wherein the transgene encodes a protein.
60. The method according to claim 59, wherein the protein is an enzyme that modifies
fatty acid metabolism and/or carbohydrate metabolism.
61. The method according to claim 57, wherein the transgene is selected from the
group consisting of nucleotide sequences encoding fructosyltransferase, levansucrase, alpha-
amylase, invertase and starch branching enzyme or encoding an antisense of stearyl-ACP
desaturase.
62. A recombinant rice plant produced by the method of claim 57.
63. A method of producing a rice plant having a desired trait, comprising:
(a) crossing a rice plant that is tolerant to aryloxyphenoxypropionate herbicides,
cyclohexanedione herbicides, phenylpyrazoline herbicides or combinations thereof at levels of
herbicide that would normally inhibit the growth of a rice plant with a plant of another rice
cultivar that comprises the desired trait to produce progeny plants;
(b) selecting one or more progeny plants that have the desired trait to produce selected
progeny plants;
(c) crossing the selected progeny plants with the herbicide-tolerant plants to produce
backcross progeny plants;
(d) selecting for backcross progeny plants that have the desired trait and herbicide
tolerance; and
(e) repeating steps (c) and (d) three or more times in succession to produce selected
fourth or higher backcross progeny plants that comprise the desired trait and herbicide tolerance.

64. A method according to claim 63, wherein the desired trait is selected from the group consisting of male sterility, herbicide tolerance, drought tolerance insect resistance, modified fatty acid metabolism, modified carbohydrate metabolism and resistance to bacterial disease, fungal disease or viral disease.

65. A method of producing a male sterile rice plant wherein the method comprises transforming a rice plant tolerant to at least one herbicide that inhibits acetyl-Coenzyme A carboxylase activity at levels of herbicide that would normally inhibit the growth of a rice plant with a nucleic acid molecule that confers male sterility.

66. A male sterile rice plant produced by the method of claim 65.

67. A composition, comprising:
one or more cells of a rice plant; and
an aqueous medium, wherein the medium comprises a compound that inhibits acetyl-Coenzyme A carboxylase activity, and wherein the cells are derived from a rice plant tolerant to aryloxyphenoxypropionate herbicides, cyclohexanedione herbicides, phenylpyrazoline herbicides or combinations thereof at levels of herbicide that would normally inhibit the growth of a rice plant.

68. A composition according to claim 67, wherein the compound comprises one or more of aryloxyphenoxypropionate herbicides, cyclohexanedione herbicides, phenylpyrazoline herbicides and combinations thereof.

69. An isolated nucleic acid molecule encoding a rice acetyl-Coenzyme A carboxylase (ACCCase) in which the amino acid sequence differs from an amino acid sequence of an acetyl-Coenzyme A carboxylase of a wild-type rice plant at one or more of the following positions: 1,781(*Am*), 1,999(*Am*), 2,027(*Am*), 2,041(*Am*), 2,078(*Am*), 2088(*Am*) or 2,096(*Am*).

70. An isolated nucleic acid molecule encoding a rice acetyl-Coenzyme A carboxylase (ACCCase) in which the amino acid sequence comprises one or more of the following: the amino acid at position 1,781(*Am*) is other than isoleucine; the amino acid at position 1,999(*Am*) is other than tryptophan; the amino acid at position 2,027(*Am*) is other than tryptophan; the amino acid at position 2,041(*Am*) is other than isoleucine; the amino acid at

position 2,078(*Am*) is other than aspartate; the amino acid at position 2088(*Am*) is other than cysteine; or the amino acid at position 2,096(*Am*) is other than glycine.

71. An isolated nucleic acid molecule encoding a rice acetyl-Coenzyme A carboxylase (ACCCase) in which the amino acid sequence comprises one or more of the following: the amino acid at position 1,781(*Am*) is leucine or alanine; the amino acid at position 1,999(*Am*) is cysteine; the amino acid at position 2,027(*Am*) is cysteine; the amino acid at position 2,041(*Am*) is asparagine; the amino acid at position 2,078(*Am*) is glycine; the amino acid at position 2088(*Am*) is Arginine or the amino acid at position 2,096(*Am*) is alanine.

72. An isolated nucleic acid molecule encoding a protein comprising SEQ ID NO:XX.

73. An herbicide-tolerant, BEP clade plant having increased tolerance to an ACCCase-inhibitor (ACCI) as compared to a wild-type variety of the plant, wherein the herbicide-tolerant plant is produced by a process comprising either:

(I) the steps of

- (a) providing BEP clade plant cells having a first, zero or non-zero level of ACCI tolerance;
- (b) growing the cells in contact with a medium to form a cell culture;
- (c) contacting cells of said culture with an ACCI;
- (d) growing ACCI-contacted cells from step (c) to form a culture containing cells having a level of ACCI tolerance greater than the first level of step (a); and
- (e) generating, from ACCI-tolerant cells of step (d), a plant having a level of ACCI tolerance greater than that of a wild-type variety of the plant; or

(II) the steps of

- (f) providing a first, herbicide-tolerant, BEP clade plant having increased tolerance to an ACCCase-inhibitor (ACCI) as compared to a wild-type variety of the plant, said herbicide-tolerant plant having been produced by a process comprising steps (a)-(e); and

- (g) producing from the first plant a second, herbicide-tolerant, BEP clade plant that retains the increased herbicide tolerance characteristics of the first plant;

thereby obtaining an herbicide-tolerant, BEP clade plant.

74. An herbicide-tolerant plant according to claim 73, wherein said plant is a member of the Bambusoideae - Ehrhartoideae subclade.

75. An herbicide-tolerant plant according to claim 73, wherein said plant is a member of the subfamily Ehrhartoideae.

76. An herbicide-tolerant plant according to claim 73, wherein the cells are in the form of a callus.

77. An herbicide-tolerant plant according to claim 73, wherein said plant is a member of the genus *Oryza*.

78. An herbicide-tolerant plant according to claim 73, wherein said plant is a member of the species *O. sativa*.

79. An herbicide-tolerant plant according to claim 73, wherein the medium does not comprise a mutagen.

80. An herbicide-tolerant plant according to claim 73, wherein said herbicide-tolerant plant expresses an acetyl-Coenzyme A carboxylase (ACCase) in which the amino acid sequence differs from an amino acid sequence of an acetyl-Coenzyme A carboxylase of a corresponding wild-type BEP clade plant at one or more of the following positions: 1,781(*Am*), 1,999(*Am*), 2,027(*Am*), 2,041(*Am*), 2,078(*Am*), 2088(*Am*) or 2,096(*Am*).

81. An herbicide-tolerant plant according to claim 73, wherein said herbicide-tolerant plant expresses an acetyl-Coenzyme A carboxylase (ACCase) in which the amino acid sequence comprises one or more of the following: the amino acid at position 1,781(*Am*) is other than isoleucine; the amino acid at position 1,999(*Am*) is other than tryptophan; the amino acid at position 2,027(*Am*) is other than tryptophan; the amino acid at position 2,041(*Am*) is other than isoleucine; the amino acid at position 2,078(*Am*) is other than aspartate; the amino acid at position 2088(*Am*) is other than cysteine; or the amino acid at position 2,096(*Am*) is other than glycine.

82. An herbicide-tolerant plant according to claim 73, wherein said herbicide-tolerant plant expresses an acetyl-Coenzyme A carboxylase (ACCase) in which the amino acid sequence comprises one or more of the following: the amino acid at position 1,781(*Am*) is leucine or alanine; the amino acid at position 1,999(*Am*) is cysteine; the amino acid at position 2,027(*Am*) is cysteine; the amino acid at position 2,041(*Am*) is asparagine; the amino acid at position 2,078(*Am*) is glycine; the amino acid at position 2088(*Am*) is arginine or the amino acid at position 2,096(*Am*) is alanine.

83. An herbicide-tolerant plant, wherein said plant is produced by the process of:

(a) crossing or back-crossing a plant grown from a seed of a plant according to claim 73 with other germplasm;

(b) growing the plants resulting from said crossing or back-crossing in the presence of at least one herbicide that normally inhibits acetyl-Coenzyme A carboxylase, at levels of the herbicide that would normally inhibit the growth of a plant; and

(c) selecting for further propagation plants resulting from said crossing or back-crossing, wherein the plants selected are plants that grow without significant injury in the presence of the herbicide.

84. An isolated nucleic acid molecule comprising a nucleotide sequence encoding a mutagenized acetyl-Coenzyme A carboxylase of a plant in the BEP clade of the Family Poaceae, in which the amino acid sequence of the mutagenized acetyl-Coenzyme A carboxylase differs from an amino acid sequence of an acetyl-Coenzyme A carboxylase of the corresponding wild-type plant at one or more of the following positions: 1,781(*Am*), 1,999(*Am*), 2,027(*Am*), 2,041(*Am*), 2,078(*Am*), 2088(*Am*) or 2,096(*Am*).

85. A nucleic acid according to claim 84, wherein the nucleic acid has been isolated from a plant by a process comprising either:

(I) the steps of

- (a) providing BEP clade plant cells having a first, zero or non-zero level of ACCase-inhibitor (ACCI) tolerance;
- (b) growing the cells in contact with a medium to form a cell culture;
- (c) contacting cells of said culture with an ACCI;

- (d) growing ACCI-contacted cells from step (c) to form a culture containing cells having a level of ACCI tolerance greater than the first level of step (a); and
 - (e) generating, from ACCI-tolerant cells of step (d), a plant having a level of ACCI tolerance greater than that of a wild-type variety of the plant; or
- (II) the steps of
- (f) providing a first, herbicide-tolerant, BEP clade plant having increased tolerance to an ACCase-inhibitor (ACCI) as compared to a wild-type variety of the plant, said herbicide-tolerant plant having been produced by a process comprising steps (a)-(e); and
 - (g) producing from the first plant a second, herbicide-tolerant, BEP clade plant that retains the increased herbicide tolerance characteristics of the first plant;
- thereby obtaining an herbicide-tolerant, BEP clade plant; and
isolating a nucleic acid from the herbicide-tolerant BEP clade plant.

86. A rice plant according to claim 4, wherein said plant expresses an acetyl-Coenzyme A carboxylase (ACCCase) in which the amino acid the amino acid at position 1,781(*Am*) is leucine or alanine and at least one of the following: the amino acid at position 2,027(*Am*) is cysteine; the amino acid at position 2,041(*Am*) is asparagine; or the amino acid at position 2,096(*Am*) is alanine.

87. A rice plant according to claim 86, plant expresses an acetyl-Coenzyme A carboxylase (ACCCase) in which the amino acid the amino acid at position 2,027(*Am*) is cysteine.

88. A rice plant according to claim 86, plant expresses an acetyl-Coenzyme A carboxylase (ACCCase) in which the amino acid the amino acid at position 2,041(*Am*) is asparagine.

89. A rice plant according to claim 86, plant expresses an acetyl-Coenzyme A carboxylase (ACCCase) in which the amino acid the amino acid at position 2,096(*Am*) is alanine.

90. A rice plant according to claim 86, plant expresses an acetyl-Coenzyme A carboxylase (ACCCase) in which the amino acid the amino acid at position 2,027(*Am*) is cysteine and the amino acid the amino acid at position 2,041(*Am*) is asparagine.

ABSTRACT OF THE DISCLOSURE

The present invention provides herbicide-tolerant plants. The present invention also provides methods for controlling the growth of weeds by applying an herbicide to which herbicide-tolerant plants of the invention are tolerant. Plants of the invention may express an acetyl-Coenzyme A carboxylase enzyme that is tolerant to the action of acetyl-Coenzyme A carboxylase enzyme inhibitors.

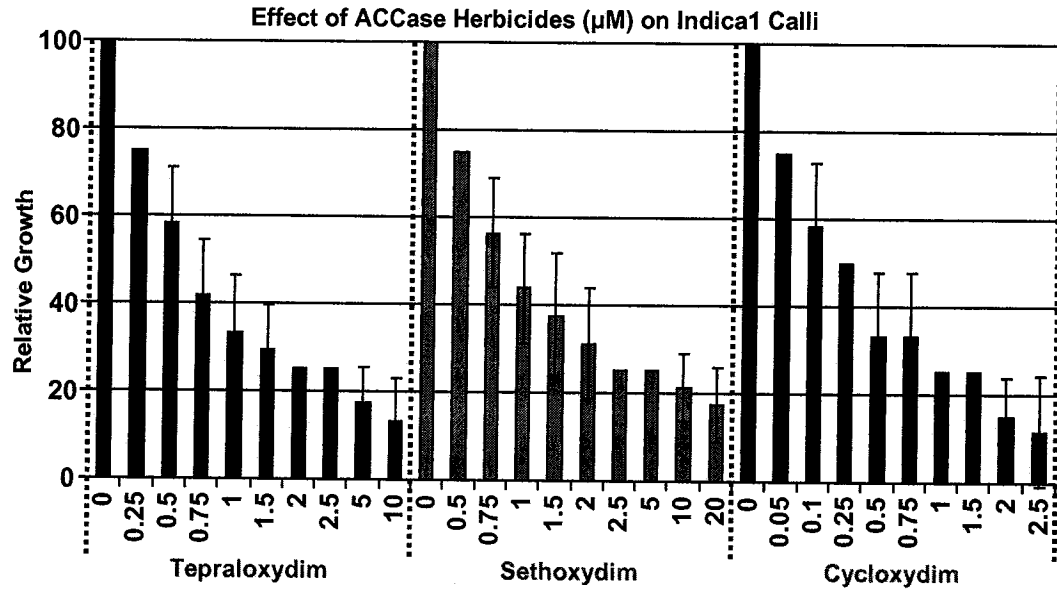
FIGURE 1

FIGURE 2

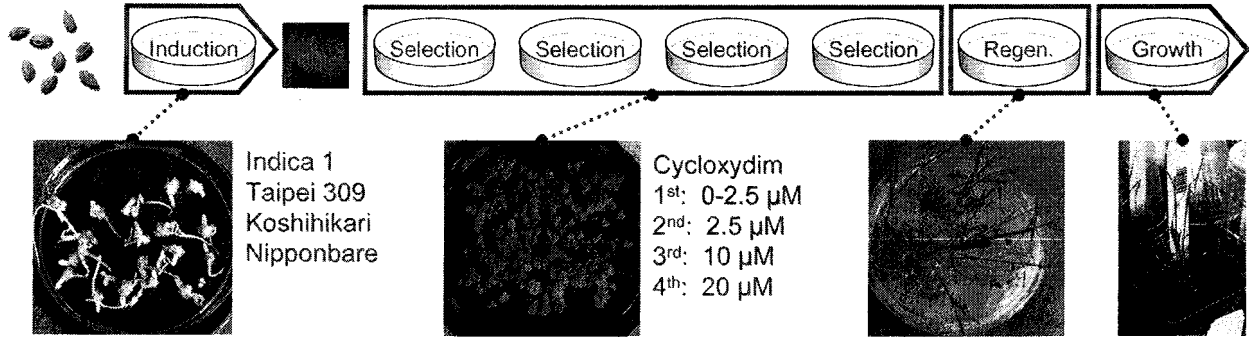


FIGURE 3

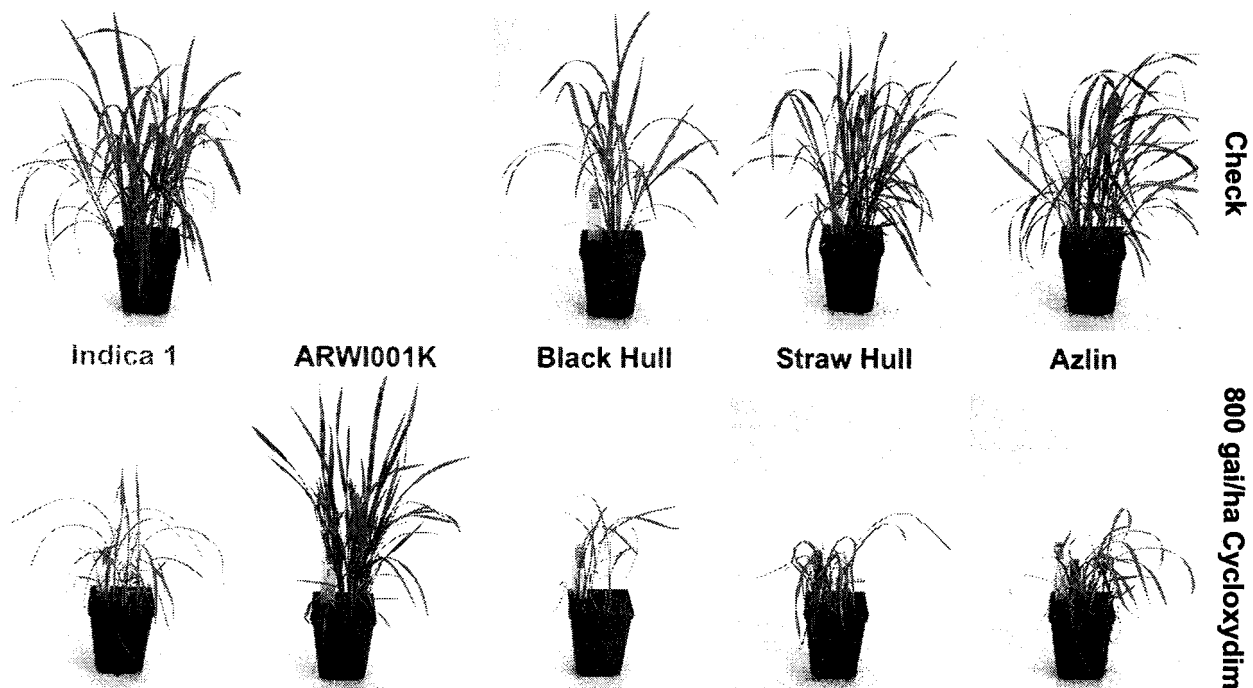


FIGURE 4

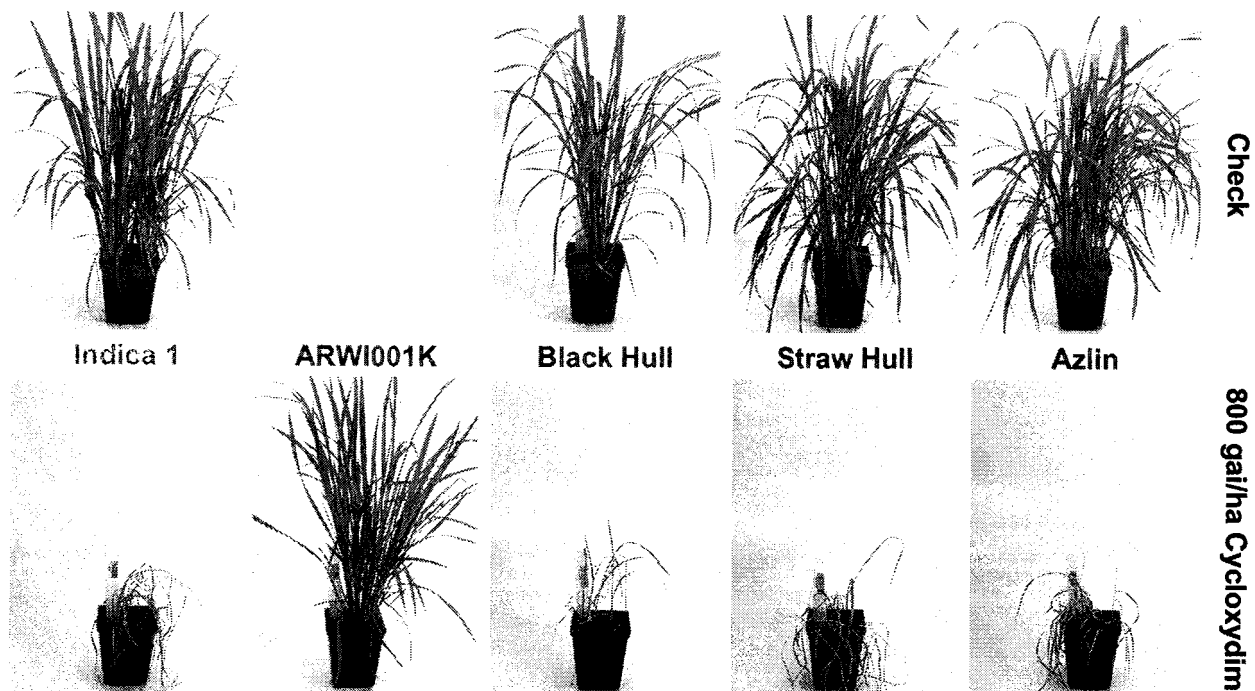


FIGURE 5

LOCUS CAC84161 2320 aa linear PLN 14-NOV-2006
 DEFINITION acetyl-coenzyme A carboxylase [Alopecurus myosuroides].
 ACCESSION CAC84161
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 DBSOURCE embl accession AJ310767.1
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 SOURCE Alopecurus myosuroides
 ORGANISM Alopecurus myosuroides
 Eukaryota; Viridiplantae; Streptophyta; Embryophyta;
 Tracheophyta;
 Spermatophyta; Magnoliophyta; Liliopsida; Poales; Poaceae; BEP
 clade; Pooideae; Aveneae; Alopecurus.
 REFERENCE 1
 AUTHORS Delye,C., Matejicek,A. and Gasquez,J.
 TITLE PCR-based detection of resistance to acetyl-CoA
 carboxylase-inhibiting herbicides in black-grass (Alopecurus
 myosuroides Huds) and ryegrass (Lolium rigidum gaud)
 JOURNAL Pest Manag. Sci. 58 (5), 474-478 (2002)
 PUBMED 11997974
 REFERENCE 2
 AUTHORS Delye,C., Calmes,E. and Matejicek,A.
 TITLE SNP markers for black-grass (Alopecurus myosuroides Huds.)
 genotypes resistant to acetyl CoA-carboxylase inhibiting
 herbicides
 JOURNAL Theor. Appl. Genet. 104 (6-7), 1114-1120 (2002)
 PUBMED 12582620
 REFERENCE 3
 AUTHORS Delye,C., Zhang,X.Q., Chalopin,C., Michel,S. and Powles,S.B.
 TITLE An isoleucine residue within the carboxyl-transferase domain of
 multidomain acetyl-coenzyme A carboxylase is a major determinant
 of
 sensitivity to aryloxyphenoxypropionate but not to
 cyclohexanedione
 inhibitors
 JOURNAL Plant Physiol. 132 (3), 1716-1723 (2003)
 PUBMED 12857850
 REFERENCE 4
 AUTHORS Delye,C., Straub,C., Michel,S. and Le Corre,V.
 TITLE Nucleotide variability at the acetyl coenzyme A carboxylase gene
 and the signature of herbicide selection in the grass weed
 Alopecurus myosuroides (Huds.)
 JOURNAL Mol. Biol. Evol. 21 (5), 884-892 (2004)
 PUBMED 15014166
 REFERENCE 5
 AUTHORS Delye,C., Zhang,X.Q., Michel,S., Matejicek,A. and Powles,S.B.
 TITLE Molecular bases for sensitivity to acetyl-coenzyme A carboxylase
 inhibitors in black-grass
 JOURNAL Plant Physiol. 137 (3), 794-806 (2005)
 PUBMED 15579665
 REFERENCE 6 (residues 1 to 2320)
 AUTHORS Delye,C.
 TITLE Direct Submission

JOURNAL Submitted (18-JUN-2001) Delye C., Malherbologie et Agronomie,
 Institut National de la Recherche Agronomique, B. P. 86510, 21035
 Dijon cedex, FRANCE

FEATURES Location/Qualifiers

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FIGURE 6

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 clade; Pooideae; Aveneae; Alopecurus.

REFERENCE 1
 AUTHORS Delye, C., Matejicek, A. and Gasquez, J.
 TITLE PCR-based detection of resistance to acetyl-CoA
 carboxylase-inhibiting herbicides in black-grass (*Alopecurus
 myosuroides* Huds) and ryegrass (*Lolium rigidum* gaud)
 JOURNAL Pest Manag. Sci. 58 (5), 474-478 (2002)
 PUBMED 11997974

REFERENCE 2
 AUTHORS Delye, C., Calmes, E. and Matejicek, A.
 TITLE SNP markers for black-grass (*Alopecurus myosuroides* Huds.)
 genotypes resistant to acetyl CoA-carboxylase inhibiting
 herbicides
 JOURNAL Theor. Appl. Genet. 104 (6-7), 1114-1120 (2002)
 PUBMED 12582620

REFERENCE 3
 AUTHORS Delye, C., Zhang, X.Q., Chalopin, C., Michel, S. and Powles, S.B.
 TITLE An isoleucine residue within the carboxyl-transferase domain
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 sensitivity to aryloxyphenoxypropionate but not to
 cyclohexanedione
 inhibitors
 JOURNAL Plant Physiol. 132 (3), 1716-1723 (2003)
 PUBMED 12857850

REFERENCE 4
 AUTHORS Delye, C., Straub, C., Michel, S. and Le Corre, V.
 TITLE Nucleotide variability at the acetyl coenzyme A carboxylase
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 and the signature of herbicide selection in the grass weed
Alopecurus myosuroides (Huds.)
 JOURNAL Mol. Biol. Evol. 21 (5), 884-892 (2004)
 PUBMED 15014166

REFERENCE 5
 AUTHORS Delye, C., Zhang, X.Q., Michel, S., Matejicek, A. and Powles, S.B.
 TITLE Molecular bases for sensitivity to acetyl-coenzyme A
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 inhibitors in black-grass
 JOURNAL Plant Physiol. 137 (3), 794-806 (2005)

PUBMED 15579665
 REFERENCE 6 (bases 1 to 6963)
 AUTHORS Delye,C.
 TITLE Direct Submission
 JOURNAL Submitted (18-JUN-2001) Delye C., Malherbologie et Agronomie,
 Institut National de la Recherche Agronomique, B. P. 86510,

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aggattacct
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6181 gtatatatcc ccaaggctgc agagctacgt ggaggagcct gggctcgtgat
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gttgctctca
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ggcctgaaa

6961 tga

//

FIGURE 7A

>OsI.ACCI [BGIOSIBCE018385]

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FIGURE 7B

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GKKYTIDTVRS GHGSYRLRMNGSTVDANVQILCDGGLLMQLDGN SHVIYAE EASGTRLLIDGKTCMLQN
DHDPSKLLAETPCKLLRFLVADGAHVADVPYAEVEVMKMCMPLLSPASGVIHVVMSEGOAMQAGDLIAR
LDLDDPSAVKRAEPFEDTFPQMGLPIAASGQVHKLCAASLNACRMILAGYEHDIDKVVPELVYCLDTPPEL
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VEPLMSLLKSYEGGRESHAHFVVKSLFEEYLYVEELFSDGIQSDVIERLRLQHSKDLQKVVDIVLSHQSV
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TEESKGLSMHKREIAIKESMEDLV TAPLPVEDALISLFDSDTTVQQRVIETYIARLYQPHLVKDSIKMK
WIESGVIALWEFPEGHF DARNGGAVLGDKRWGAMVIVKSLESLSMAIRFALKETSHYTSSEGNMMHIALL
GADNMHI IQESGDDADRIAKLPLILKDNVTDLHASGVKTI SFIVQRDEARMTMRRTFLWSDEKLSYEEE
PILRHVEPPLSALLELDKLVKGYNEMKYTPSRDRQWHIYTLRNTENPKMLHRVFFRTLVRQPSVSNKFS
SGQIGDMEVGSAAEPLSFTSTSI LRSLMTAIEEELHAI RTGHSHMYLHVLKEQKLLDLVPVSGNTVLDV
GQDEATAYSLLKEMAMKIH ELVGARMHHSVCQWEVKLKLDCDGPASGTWRIVTTNVT SHTCTVDIYREM
EDKESRKL VYHPATPAAGPLHGVALNPNYQPLSVIDLKRCSARNRRTTYCYDFPLAFETA VRKSWSSSTS
GASKGVENAQC YVKATELVFADKHGSGWGTPLVQMDR PAGLNDIGMVAWTLKMSTPEFPGREIIVVANDI
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FIGURE 8B

>OsjACCI [EAZ33685]
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 AGIIDLPNDAASEVDISHGSEDPGPTVPGSYQMNGIINETHNGRHASVSKVVEFCTALGGKTPIHVSVLV
 ANNGMAAAKFMRSVRTWANDTFGSEKAIQLIAMATPEDLRINAHEHIRIADQFVEVPGGTNNNNYANVQLI
 VEIAERTGVSAVWPGWGHASENPELDPALTAKGIVFLGPPASSMHALGDKVGSALIAQAAGVPTLAWSGS
 HVEVPLECCLDSIPDEMYRKACVTTTEEAVASCQVVGYPAMIKASWGGGGKIRKVVHNDDEVRTLKQVQ
 GEVPGSPIFIMRLAAQSRHLEVQLLCDQYGNVAALHSRDCSVQRRHQKIIIEGPVTVAPRETVKELEQAA
 RRLAKAVGYVGAATVEYLYSMETGEYYFLELNPRLQVEHPVTEWIAEVNLPAAQVAVGMGIPLWQIPEIR
 RFYGMNHGGGYDLWRKTAALATPFNFDEVDSKWPKGHCVAVRITSEDPDDGFKPTGGKVKEISFKSKPNV
 WAYFSVKSGGGIHEFADSQFGHVFAYGTTTSAAITTMALALKEVQIRGEIHSNVDYTVDLLNASDFRENK
 IHTGWLDTRIAMRVQAERPPWYISVVGALYKTVTANTATVSDYVGYLTKGQIPPKHISLVYTTVALNID
 GKKYTIDTVRSGHGSYRLRMNGSTVDANVQILCDGGLLMQLDGNSHVIYAEESAGTRLLIDGKTCMLQN
 DHDP SKLLAETPCKLLRFLVADGAHVADVPYAEVEVMKMCMPLLSPASGVIHVVMSEGOAMQAGDLIAR
 LDLDPSAVKRAEPFEDTFFQMGLPIAASGQVHKLCAASLNACRMILAGYEHDIDKVPELVYCLDTPEL
 PFLQWEELMSVLATRLPRNLKSELEGKYEYKVKFDSGIINDFPANMLRVIIEENLACGSEKEKATNERL
 VEPLMSLLKSYEGGRESHAHFVVKSLFEEYLYVEELFSDGIQSDVIERLRLQHSKDLQKVVDIVLSHQSV
 RNKTKLILKLMEVLVYPNPAAYRDQLIRFSSLNHKAYYKLALKASELLEQTKLSELRARIARSLSELEMF
 TEESKGLSMHKREIAIKESMEDLVTAPLPVEDALISLFDSDTTVQQRVIETYIARLYQPHLVKDSIKMK
 WIESGVIALWEFPEGHFADARNGGAVLGDKRWGAMVIVKSLESLSMAIRFALKETSHYTSSEGNMMHIALL
 GADNMHI IQESGDADRIAKLPLILKDNVTDLHASGVKTI SFIVQRDEARMTMRRTFLWSDEKLSYEEE
 PILRHVEPPLSALLELDKLVKGYNEMKYTPSRDRQWHIYTLRNTENPKMLHRVFFRTLVRQPSVSNKFS
 SGQIGDMEVGSAAEPLSFTSTSLRSLMTAIEEELHAI RTGHSHMYLHVLKEQKLLDLVPVSGNTVLDV
 GODEATAYSLKEMAMKIHVGVARMHLSVCQWEVKKLDCDGPASGTWRIVTTNVTSHCTVDIYREM
 EDKESRKL VYHPATPAAGPLHGVALNPNYQPLSVIDLKRCSARNRRTTYCYDFPLAFETA VRKSWSSSTS
 GASKGVENAQC YVKATELVQMDRLAGLNDIGMVAWTLKMSTPEFLSGREIIVVANDITFRAGSFGPREDA
 FFEAVTNLACEKKLPLIYLAANS GARIGIADEVKSCFRVGSDDGS PERGFQYIYLSEEDYARIGTSVIA
 HKMQLD SGEIRWVIDSVVGKEDGLGVENIHGSAAIASAYS RAYKETFTLTFTVTRTVGIGAYLARLGIRC
 IQRLDQPI IILTGY SALNKLLGREVYSSHMQLGGPKIMATNGVVHLTVSDDLEGVSNILRWLSYVPAYIGG
 PLPVTTPLDPPDRPVAYI PENS CD PRAAIRGVDDSQGKWLGGMFDKDSFVETFEGWAKTVVTGRAKLGGI
 PVGVIAVETQ TMMQTI PADPGQLDSREQS VPRAGQVWF PDSATKTAQALLDFNREGLPLFILANWRGFSG
 GQRDLFEGILQAGSTIVENLR TYNQPAFVYI PMAAELRGGAWVVVDSKINPDRIECYAERTAKGNVLEPQ
 GLIEIKFRSEELQDCMSRLDPTLIDLKAKLEVANKNGSADTKSLQENI EARTKQLMPLYTQIAIRFAELH
 DTSLRMAAKGVIKKVVDWEESRSFFYKRLRRRI SEDVLAKEIRAVAGEQF SHQPAIELIKKWYSASHAAE
 WDDDDAFVAMDNPENYKDYIQYLKAQRVSQSLSSLSDDSSDLQALPQGLSMLLDKMDPSRAAQLVEEIR
 KVLG

FIGURE 9A

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 GGCCAACAGATTCTTATCAAATGAATGGGATTATCAATGAAACACATAATGGAAGACATGCCTCAGTGTC
 CAAGGTTGTTGAATTTTGTGCGGCCTAGGTGGCAAACACCAATTACAGTATATTAGTGGCCAACAAT
 GGAATGGCAGCAGCAAAATTTATGAGGAGTGTCCGGACATGGGCTAATGATACTTTTGGATCTGAGAAGG
 CAATTCAACTCATAGCTATGGCAACTCCGGAAGACATGAGGATAAATGCAGAACACATTAGAATTGCTGA
 CCAATTCGTAGAGGTGCCTGGTGGAAACAAAATAAATAACTACGCCAATGTTCAACTCATAGTGGAGATG
 GCACAAAACCTAGGTGTTTCTGCTGTTTGGCCTGGTTGGGGTCATGCTTCTGAGAATCCTGAACTGCCAG
 ATGCATTGACCGCAAAGGGATCGTTTTTCTTGGCCACCTGCATCATCAATGAATGCTTTGGGAGATAA
 GGTCCGCTCAGCTCTCATTGCTCAAGCAGCCGGGGTCCCAACTCTTGCTCGGAGTGGATCACATGTTGAA
 GTTCCATTAGAGTGCTGCTTAGACGCGATACCTGAGGAGATGTATAGAAAAGCTTGCCTTACTACCACAG
 AGGAAGCAGTTGCAAGTTGTCAAGTGGTTGGTTATCCTGCCATGATTAAGGCATCCTGGGGAGGTGGTGG
 TAAAGGAATAAGAAAGGTTTATAATGATGATGAGGTTAGAGCGCTGTTTAAAGCAAGTACAAGGTGAAGTC
 CCTGGCTCCCAATATTTGTGCATGAGGCTTGCATCCAGAGTCCGGCATCTTGAAGTTTCAAGTTGCTTTGTG
 ATCAATATGGTAATGTAGCAGCACTTACAGTCTGATTGCAAGTGTGCAACGGCGACACCAGAAGATTAT
 TGAAGAAGGTCCAGTTACTGTTGCTCCTCGTGAGACAGTTAAAGCACTTGAGCAGGCAGCAAGGAGGCTT
 GCTAAGGCTGTGGGTTATGTTGGTGTGCTACTGTTGAGTATCTTTACAGCATGGAAACTGGAGACTACT
 ATTTTCTGAACTTAATCCCCGACTACAGGTTGAGCATCCAGTCCAGGAGTGGATAGCTGAAGTAAATCT
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 GGCTCTCTAGATCAGCAGCAATAACAAAACATGACTCTTGCATTAAAAGAGATTCAAATTCGTGGAGAAAT
 TCATTCAAATGTTGATTACACAGTTGACCTCTTAAATGCTTCAAGCTTTAGAGAAAACAAGATTACTACT
 GGTGGCTCGACACCAGAATAGCTATGCGTGTTCAGCTGAGAGGCCCCATGGTATATTTTCAAGTGGTTG
 GAGGTGCTTTATATAAAAACAGTAACCACCAATGCAGCCACTGTTTCTGAATATGTTAGTTATCTCACCAA
 GGGCCAGATTCCACCAAAGCATATATCCCTTGTCAATTCTACAGTTAATTTGAATATAGAAGGGAGCAA
 TACACAATTGAACTGTAAGGACTGGACATGGTAGCTACAGGTTGAGAATGAATGATTCAACAGTTGAAG
 CGAATGTACAATCTTTATGTGATGGTGGCCTCTTAATGCAGTTGGATGGAAAACAGCCATGTAATTTATGC
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TCACTTTTAAATCAATGGCTTTGAAGATACATGAGCTTGTGGTGCAAGGATGCATCATCTGTCTGTAT
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TGACGAAGGCAAGTCTGAACGAGGGTTTTCAGTACATCTATCTGACTGAAGAAGACTATGCTCGCATTAGC
TCTTCTGTTATAGCACATAAGCTGGAGCTAGATAGTGGTGAATTAGGTGGATTATTGACTCTGTTGTGG
GCAAGGAGGATGGGCTTGGTGTGAGAACATACATGGAAGTGTGCTATTGCCAGTGTCTATTCTAGGGC
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GTCTGAAAACACTACAAGGGGCATATCCAAAAGCTTAGGGCTCAAAAAGTGTCTCATTGCTCTCTGATCT
TGCTGACTCCAGTTGAGATCTGCAAGCATTCTCGAGGGTCTTTCTACGCTATTAGATAAGATGGATCCC
TCTCAGAGAGCGAAGTTTTGTTGAGGAAGTCAAGAAGGTCTTTGATTGA

FIGURE 9B

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MSQLGLAAAASKALPLLPNRQRSSAGTTFFSSSSLSRPLNRRKSR
 TRSLRDGGDGVSDAKKHSQSVRQGLAGIIDLPSEAPSEVDISHGSEDPRGPTDSYQMN
 GIINETHNGRHASVSKVVEFCAALGGKTPIHSLVANNMGMAAAKFMRSVRTWANDTFG
 SEKAIQLIAMATPEDMRINAEHIRIADQFVEVPGGTNNNNYANVQLIVEMAQKLGVSA
 VWPGWGHASENPELDPALTAKGIVFLGPPASSMNALGDKVGSALIAQAAGVPTLARS
 SHVEVPLECCLDAIPEEMYRKACVT'TTEEAVASCQVVGYPAMIKASWGGGGKIRKVH
 NDDEVRALFKQVQGEVPGSPIFVMRLASQSRHLEVQLLCDQYGNVAALHSRDCSVQRR
 HQKIEEGPVTVAPRETVKALEQAARRLAKAVGYVGAATVEYLYSMETGDYYFLELNP
 RLQVEHPVTEWIAEVNLPAAQVAVGMGIPLWQIPEIRRFYGM DYGGGYDIWRKTAALA
 TPFNFDEVDSQWPKGHCVAVRITSEDPDDGFKPTGGKVKEISFKSKPNVWAYFSVKS
 GGIHEFADSQFGHVFAVGLSRSAAITNMTLALKEIQIRGEIHSNVDYTVDLLNASDFR
 ENKIHTGWLDRIAMRVQAERPPWYISVVGALYKTVTTNAATVSEYVSYLTGQIIPP
 KHISLVNSTVNLNIEGSKYTIETVRTGHGSYRLRMNDSTVEANVQSLCDGGLLMQLDG
 NSHVIYAEAEAGGTRLQIDGKTCLLQNDHDPKLLAETPCKLLRFLVADGAHVADAVP
 YAEVEVMKMCMPLLSPASGVIHCMMSEGOALQAGDLIARLDLDDPSAVKRAEFPDGFIF
 PQMELPVAVSSQVHKRYAASLNAARMVLAGYEHNINEVVQDLVCCLDNPELPFLQWDE
 LMSVLAATRLPRNLKSELEDKYKEYKLNIFYHGNEDFPSKLLRDIIEENLSYGSEKEKA
 TNERLQVEPLMNLKSEYEGRESHAFVVKSLFEEYLTV EELFSDGIQSDVIETLRHQH
 SKDLQKVVVDIVLSHQGVRNKAKLVTALMEKLVYPNPGGYRDLVRFSSLNHKRYKLA
 LKASELLEQTKLSELRASVARSLSDLGMHKGEMSIKDNMEDLVSAPLPVEDALISLFD
 YSDRTVQKFIETYISRLYQPHLVKDSIQMKFKESGATTFWEFYEGHVDTRNGHGAII
 GKRWGAMVVLKSLESASTAIVAALKDSAQFNSSEGNMMHIALLSAENESNISGISD
 DQAQHKMEKLSKILKDTSVASDLQAAGLVISCIQRDEARMPMRHTFLWLDDKSCYE
 EEQILRHVEPPLSTLLELDKLVKGYNEMKYTPSRDRQWHIYTLRNTENPKMLHRVFF
 RTIVRQPNAGNKFTSAQISDAEVCPEESLSFTSNSILRSLMTAIEEELHAI RTGHS
 HMYLCILKEQKLLDLIPFGSGTIVDVGQDEATACSLKSMALKIHELVGARMHHL SVC
 QWEVKLKLDCDGPASGTWRVVTNTVTGHTCTIDIYREVEEIESQKLVYHSATSSAGPL
 HGVALNNPYQPLSVIDLKRC SARNNRTTYCYDFPLAFETALQKSWQSNGSTVSEGNEN
 SKSYVKATELVFAEKHGSWGTPIIPMERPAGLNDIGMVAWIMEMSTPEFPNGRQIIIV
 ANDITFRAGSFGPREDAFFETVTNLACERKLP LIYLAANSGARIGIADDEVKSCFRVGV
 SDEGSPERGFQYIYLTEEDYARISSSVIAHKLELDSGEIRWIIDSVVGKEDGLGVENI
 HGSAAIASAYSRAYEETFTLTFVTGRTVIGAYLARLGIRCIQRDQPIILTGFSALN
 KLLGREVYSSHMQLGGPKIMATNGVVHLTVPDLEGVSNILRWLSYVPANIGGPLPIT
 KPLDPPDRPVAYIPENTCDPRAAICGVDDSQGKWLGGMFDKDSFVETFEGWAKTVVTG
 RAKLGGIPVGVIAVETQTMQIIPADPGQLDSHERSVPRAGQVWFPSATKTAQALLD
 FNREGLPLFILANWRGFGGQRDLFEGILQAGSTIVENLRTSNQP AFVYIPMAGELRG
 GAWVVVDSKINPDRIECYAERTAKGNVLEPQGLIEIKFRSEELQDCMGRDPELINLK
 AKLQDVNHGNSLPDIEGIRKSIEARTKQLLPLYTQIAIRFAELHDTSLRMAAKGVK
 KVVWDWEESRSFFYKRLRRRIAEDVLAKEIRQIVGDKFTHQLAMELIKEWYLASQATTG
 STGWDDDDAFVAWKDSPENYKGHIQKLRQAVSHSLSDLADSSSDLQAFSQGLSTLLD
 KMDPSQRAKFVQEVKKVLD

FIGURE 10A

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ATGTCACAGCTTGGATTAGCCGCGAGCTGCCTCAAAGGCCTTGCCACTACTCCCTAATCGCCAGAGAAGTT
 CAGCTGGGACTACATTTCTCATCATCTTCATTATCGAGGCCCTTAAACAGAAGGAAAAGCCGTA CTCTCGTTTC
 ACTCCGTGATGGCGGAGATGGGGTATCAGATGCCAAAAGCACAGCCAGTCTGTTTCGTCAAGGTCTTGCT
 GGCATTATCGACCTCCAAGTGAGGCACCTTCCGAAGTGGATATTTACATGGATCTGAGGATCCTAGGG
 GGCCAACAGATTCTTATCAAATGAATGGGATTATCAATGAAACACATAATGGAAGACATGCCTCAGTGT
 CAAGTTTGTGAATTTTGTGCGGCACTAGGTGGCAAAACACCAATTCACAGTATATTAGTGGCCAACAAT
 GGAATGGCAGCAGCAAAATTTATGAGGAGTGCAGGACATGGGCTAATGATACTTTTGGATCTGAGAAG
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 CCTGGCTCCCCAATATTTGTCTATGAGGCTTGCATCCAGAGTCCGCATCTTGAAGTTTCAAGTTGCTTTGTG
 ATCAATATGGTAATGTAGCAGCACTTCACAGTCGTGATTGCAGTGTGCAACGGCGACACCAGAAGATTAT
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 GCTAAGGCTGTGGGTTATGTTGGTGTCTACTGTTGAGTATCTTTACAGCATGGAAACTGGAGACTACT
 ATTTTCTGAACTTAATCCCCGACTACAGGTTGAGCATCCAGTCACCGAGTGGATAGCTGAAGTAAATCT
 GCCTGCAGCTCAAGTTGCTGTTGGAATGGGCATACCTCTTTGGCAGATTCCAGAAATCAGACGTTTTCTAT
 GGAATGGACTATGGAGGAGGGTATGACATTTGGAGGAAAACAGCAGCTCTTGCTACACCATTTAATTTTG
 ATGAAGTACATTTCTCAATGGCCAAAGGGCCATTTGTGTAGCAGTTAGAATTACTAGTGGAGCCAGATGA
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 GGCTCTCTAGATCAGCAGCAATAACAAACATGACTCTTGCATTAAAAGAGATTCAAATTCGTGGAGAAAT
 TCATTCAAATGTTGATTACACAGTTGACCTCTTAAATGCTTCAGACTTTAGAGAAAACAAGATTATACT
 GGTGGCTCGACACCAGAATAGCTATGCGTGTTCAGCTGAGAGGCCCCCATGGTATATTTTCAAGTGGTTG
 GGGGTGCTTTATATAAAAACAGTAACCACCAATGCAGCCACTGTTTCTGAATATGTTAGTTATCTACCAA
 GGGCCAGATTTCCACCAAAGCATATATCCCTTGTCAATTCTACAGTTAATTTGAATATAGAAGGGAGCAA
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 ATGCGGATGTACCATACGCGAAGTTGAGGTTATGAAGATGTGCATGCCTCTCTTGTGCGCTGCTTCTGG
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 TCATCTTGTAAAGGATAGCATCCAAATGAAATTCAGGAATCTGGTGTCTATTACTTTTTGGGAATTTTAT
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 TTCTCAAATCACTTGAATCTGCGTCAACAGCCATTGTGGCTGCATTAAAGGATTCCGGCACAGTTCAACAG
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CACATTCCTCTGGTTGGATGACAAGAGTTGTATGAAGAAGAGCAGATTCTCCGGCATGTGGAGCCTCCC
CTCTCTACACTTCTTGAATTGGATAAGTTGAAGGTGAAAGGATACAATGAAATGAAGTATACTCCTTTCGC
GTGACCGCCAATGGCATATCTACACACTAAGAAAATACTGAAAAACCCAAAATGTTGCATAGGGTGTTTTT
CCGAACTATTGTGAGGCAACCCAATGCAGGCAACAAGTTTACATCGGCTCAGATCAGCGACGCTGAAGTA
GGATGTCCGAAGAATCTCTTTTCAATTTACATCAAATAGCATCTTAAGATCATTGATGACTGCTATTGAAG
AATTAGAGCTTCATGCAATTAGGACAGGTCAATCTCACATGTATTTGTGCATACTGAAAGAGCAAAAAGCT
TCTTGACCTCATTCATTTTTAGGGAGTACAATTGTTGATGTTGGCCAAGATGAAGCTACCGCTTGTTC
CTTTTAAAATCAATGGCTTTGAAGATACATGAGCTTGTGGTGCAGGATGCATCATCTGTCTGTATGCC
AGTGGGAGGTGAAACTCAAGTTGGACTGTGATGGCCCTGCAAGTGGTACCTGGAGAGTTGTAACACAAA
TGTTACTGGTTCACACTGCACCATTGATATATAACCGAGAAGTGGAGGAAATAGAATCGCAGAAGTTAGTG
TACCATTGAGCCACTTCGTGAGCTGGACCATTGCATGGTGTGCACTGAATAATCCATATCAACCTTTGA
GTGTGATTGATCTAAAGCGCTGCTCTGCTAGGAAACAAGAAACAATATTGCTATGATTTTTCCGCTGGC
CTTTGAACTGCACTGCAGAAGTCATGGCAGACCAATGGCTCTACTGTTTTCTGAAGGCAATGAAAATAGT
AAATCCTACGTGAAGGCAACTGAGCTAGTGTGTTGCTGAAAAACATGGGTCTGGGGCACTCCTATAATTC
CGATGGAACGCCCTGCTGGGCTCAACGACATTTGGTATGGTCTGGATCATGGAGATGTCAACACCTGA
ATTTCCCAATGGCAGGCAGATTATTTGTTGTAGCAAATGATATCACTTTGAGAGCTGGATCATTTGGCCCA
AGGGAAGATGCATTTTTTGAAGTGTCACTAACCTGGCTTGGCAAAGGAAACTTCTCTTATATACTTGG
CAGCAAACCTCTGGTGTAGGATTGGCATAGCTGATGAAGTAAAATCTTGCTTCCGTGTTGGATGGTCTGA
CGAAGGCAGTCTGAAACGAGGGTTTTCAGTACATCTATCTGACTGAAGAAGACTATGCTCGCATTAGCTCT
TCTGTTATAGCACATAAGCTGGAGCTAGATAGTGGTGAATTAGGTGGATTATTGACTCTGTTGTGGGCA
AGGAGGATGGGCTTGGTGTGAGAAACATACATGGAAGTGTGCTATTGCCAGTGCTTATTCTAGGGCATA
TGAGGAGACATTTACACTTACATTTGTGACTGGGCGGACTGTAGGAATAGGAGCTTATCTTGCTCGACTT
GGTATACGGTGCATACAGCGTCTTGACCAGCCTATTATTTTAAACAGGGTTTTCTGCCCTGAACAAGCTCC
TTGGGCGGGAAGTGTACAGCTCCACATGCAGCTTGGTGGTCTTAAGATCATGGCGACTAATGGTGTGTT
CCACCTCACTGTTCCAGATGACCTTGAAGGTGTTTTCAAATATATTGAGGTGGCTCAGCTATGTTCTCTG
AACATTTGGTGGACCTTCTCTATTACCAAACCTCTGGACCTCCAGACAGACCTGTTGCTTACATCCCTG
AGAACACATGCGATCCACGTGCAGCTATCTGTGGTGTAGATGACAGCCAAGGGAAATGGTTGGGTGGTAT
GTTTTGACAAAGACAGCTTTTGTGGAGACATTTGAAGGATGGGCAAAAACAGTGGTTACTGGCAGAGCAAAG
CTTGGAGGAATTCCTGTGGGCGTCATAGCTGTGGAGACACAGACCATGATGCAGATCATCCCTGCTGATC
CAGGTGAGCTTGATTCCCATGAGCGATCTGTCCCTCGTGTGGACAAGTGTGGTTCCCAGATTCTGCAAC
CAAGACCGCTCAGGCATTATTAGACTTCAACCGTGAAGGATTGCCTCTGTTTATCCTGGCTAATTGGAGA
GGCTTCTCTGGTGGACAAAGAGATCTCTTTGAAGGAATTTCTTCAAGGCTGGGTCAACAATTGTGAGAAC
TTAGGACATATAATCAGCCTGCTTTTGTGTACATTTCTATGGCTGGAGAGCTTCTGTGGAGGAGCTTGGGT
TGTGGTTCGATAGCAAATAAATCCAGACCGCATTTGAGTGTATGCTGAAAGGACTGCCAAAGGTAATGTT
CTCGAACCTCAAGGGTTAATTGAAATCAAGTTCAAGTTCAGGTCAGAGGAACTCCAAGACTGTATGGGTAGGCTTG
ACCCAGAGTTGATAAATCTGAAAGCAAACTCCAAGATGTAAATCATGAAATGGAAGTCTACCAGACAT
AGAAGGGATTGGAAGAGTATAGAAGCACGTACGAAACAGTTGCTGCCTTTATATACCCAGATTGCAATA
CGGTTTTGCTGAATTGCATGATACTTCCCTAAGAATGGCAGCTAAAGGTGTGATTAAGAAAGTTGTAGACT
GGGAAGAATCACGCTCGTTCTTCTATAAAAGGCTACGGAGGAGGATCGCAGAAGATGTTCTTGCAAAAAGA
AATAAGGCAGATAGTGGTGATAAATTTACGCACCAATTAGCAATGGAGCTCATCAAGGAATGGTACCTT
GCTTCTCAGGCCACAACAGGAAGCACTGGATGGGATGACGATGATGCTTTTGTGCTGGAAGGACAGTC
CTGAAAACACTAAGGGGCATATCCAAAAGCTTAGGGCTCAAAAAGTGTCTCATTGCTCTCTGATCTTGC
TGACTCCAGTTCAGATCTGCAAGCATTCTCGCAGGGTCTTCTACGCTATTAGATAAGATGGATCCCTCT
CAGAGAGCGAAGTTTGTTCAGGAAGTCAAGAAGGTCCTTGATTGA

FIGURE 10B

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>AAP78896_Zea mays
MSQLGLAAAASKALPLLPNRQRSSAGTTFFSSSSLSRPLNRRKSR
TRSLRDGGDGVSDAKKHSQSVRQGLAGIIDLPEAPSEVDISHGSEDPRGPTDSYQMN
GIINETHNGRHASVSKVVEFCAALGGKTPIHLSILVANNGMAAAKFMRSVRTWANDTFG
SEKAIQLIAMATPEDMRINAEHIRIADQFVEVPGGTNNNNYANVQLIVEMAQKLGVSA
VWPGWGHASENPELDPALTAKGIVFLGPPASSMNALGDKVGSALIAQAAGVPTLAWSG
SHVEVPLECCLDAIPEEMYRKACVTTTTEEAVASCQVVGYPAMIKASWGGGGKIRKVH
NDDEVRALFKQVQGEVPGSPIFVMRLASQSRHLEVQLLCDQYGNVAALHSRDCSVQRR
HQKIEEGPVTVAPRETVKALEQAARRLAKAVGYVGAATVEYLYSMETGDYYFLELNP
RLQVEHPVTEWIAEVNLPAAQVAVGMGIPLWQIPEIRRFYGM DYGGYDIWRKTAALA
TPFNFDEVDSQWPKGHCVAVRITSEDPDDGFKPTGGKVKEISFKSKPNVWAYFSVKSG
GGIHEFADSQFGHVFAYGLSRSAAITNMTLALKEIQIRGEIHSNVDYTVDLLNASDFR
ENKIHTGWLDTRIAMRVQAERPPWYISVVGALYKTVTTNAATVSEYVSYLTKGQIPP
KHISLVNSTVNLNIEGSKYTIETVRTGHGSYRLRMNDSTVEANVQSLCDGGLLMQLDQ
NSHVIYAEAEAGGTRLQIDGKTCLLQNDHDPKLLAETPCKLLRFLVADGAHVADAVP
YAEVEVMKMCMPLLSPASGVIHCMMSEGQALQAGDLIARLDLDDPSAVKRAEPFDGIF
PQMELPVAVSSQVHKRYAASLNAARMVLAGYEHNINEVVQDLVCCLDNPELPFLOWDE
LMSVLATRLPRNLKSELEDKYKEYKLNIFYHGKNEFSPKLLRDIIEENLSYGSEKEKA
TNERLVEPLMNLKSYEGGRESHAHFVVKSLFEEYLTVEELFSDGIQSDVIETLRHQH
SKDLQKVVDIVLSHQGVRNKAKLVTALMEKLVYPNPGGYRDLVRFSSLNHKRYYKLA
LKASELLEQTKLSELRASVARSLSDLGMHKGEMSIKDNMEDLVSAPLPVEDALISLFD
YSDRTVQQKVIETYISRLYQPHLVKDSIQMKFKESGAI TFWEFYEGHVDTRNGHGAII
GGKRWGAMVVLKSLESASTAIVAALKDSAQFNSSEGNMMHIALLSAENESNISGISDD
QAQHKMEKLSKILKDTSVASDLQAAGLKVISCIVQRDEARMMPMRHTFLWLDDKSCYEE
EQILRHVEPPLSTLLELDKLVKGYNEMKYTPSRDRQWHIYTLRNTENPKMLHRVFFR
TIVRQPNAGNKFTSAQISDAEVCPEESLSFTSNSILRSLMTAIEEELHAIRTGHS
MYLCILKEQKLLDLIPFSGSTIVDVGQDEATACSLKSMALKIHEL VGARMHHSVCQ
WEVKLKLDCDGPASGTWRVVTTNVTGHTCTIDIYREVEEIESQKLVYHSATSSAGPLH
GVALNPNYQPLSVIDLKRCSARNRNTTYCYDFPLAFETALQKSWQTNGSTVSEGNENS
KSYVKATELVFAEKHGSWGTPPIIPMERPAGLNDIGMVAWIMEMSTPEFPNGRQIIVVA
NDITFRAGSFGPREDAFFETVTNLACERKPLIYLAANS GARIGIADDEVKSCFRVGS
DEGSPERGFQYIYLTEEDYARISSSVIAHKLELDSGEIRWIIDSVVGKEDGLGVENIH
GSAAIASAYSRA YEETFTLTFVTGRTVGIGAYLARLGIRCIQRLDQPIILTGFSALNK
LLGREVYSSHMQLGGPKIMATNGVVHLTVPDDLEGVSNILRWLSYVPANIGGPLPITK
PLDPPDRPVAYIPENTCDPRAAICGVDDSQGKWLGGMFDKDSFVETFEGWAKTVVTGR
AKLGGIPVGVIAVETQTMQIIPADPGQLDSHERSVPRAGQVWFPDSATKTAQALLDF
NREGLPLFILANWRGFGSGQRDLFEGILQAGSTIVENLRTYNQPAFVYIPMAGELRGG
AWVVVDSKINPDRIECYAERTAKGNVLEPQGLIETIKFRSEELQDCMGRLDPELINLKA
KLQDVNHGNGSLPDIEGIRKSIEARTKQLLPLYTQIAIRFAELHDTSLRMAAKGVIKK
VVDWEEERSFFYKRLRRRIAEDVLAKEIRQIVGDKFTHQLAMELIKEWYLASQATTGS
TGWDDDDAFVAWKDSPENYKGHIQKLRAQKVSHSLSDLADSSSDLQAFSQGLSTLLDK
MDPSQRAKQVQEVKKVLD

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FIGURE 11A

>AF029895_Triticum aestivum

ATGGGATCCACACATTTGCCCATTTGTCGGCCTTAATGCCTCGACAACACCATCGCTATCCACTATTGCC
 CGGTAAATTCAGCCGGTGTGCTGCATTCCAACCATCTGCCCTTCTAGAACCTCCAAGAAGAAAAGTCTGCG
 TGTTTCAGTCATTAAGGGATGGAGGCGATGGAGGCGTGTGAGCCCTAACAGTCTATTCGCCAAGGTCTT
 GCCGGCATCATTGACCTCCCAAAGGAGGGCACATCAGCTCCGGAAGTGGATATTTACATGGGTCCGAAG
 AACCCAGGGGCTCCTACCAAATGAATGGGATACTGAATGAAGCACATAATGGGAGGCATGCTTCGCTGTC
 TAAGGTTGTCGAATTTTGTATGGCATTGGGCGGCAAAACACCAATTCACAGTGTATTAGTTGCGAACAAAT
 GGAATGGCAGCAGCTAAGTTCATGCGGAGTGTCCGAACATGGGCTAATGAAACATTTGGGTGAGAGAAGG
 CAATTCAGTTGATAGCTATGGCTACTCCAGAAGACATGAGGATAAAATGCAGAGCACATTAGAATTGCTGA
 TCAATTTGTTGAAGTACCCGGTGGAAACAAACAATAACAACATATGCAAATGTCCAACCATAGTGGAGATA
 GCAGTGAGAACCGGTGTTTCTGCTGTTTGGCCTGGTTGGGGCCATGCATCTGAGAATCCTGAACTTCCAG
 ATGCACTAAATGCAAACGGAATGTTTTTCTTGGGCCACCATCATCATCAATGAACGCACTAGGTGACAA
 GGTTGGTTTCAGCTCTCATTGCTCAAGCAGCAGGGGTTCCGACTCTTCTTGGAGTGGATCACAGGTGGAA
 ATTCATTAGAAGTTTGTGGACTCGATACCCGCGGAGATGTATAGGAAAGCTTGTGTTAGTACTACGG
 AGGAAGCACTTTCGAGTGTGTCAGATGATTGGGTATCCCGCCATGATTAAGCATCATGGGGTGGTGGTGG
 TAAAGGGATCCGAAAGGTTAATAATGACGATGATGTGAGAGCACTGTTTAAAGCAAGTGAAGGTGAAGTT
 CCTGGCTCCCAATATTTATCATGAGACTTGCATCTCAGAGTCGACATCTTGAAGTTCAGTTGCTTTGTG
 ATCAATATGGCAATGTAGCTGCGCTTCACAGTCGTGACTGCAGTGTGCAACGGCGACACCAAAGATTAT
 TGAGGAAGGACCAGTTACTGTTGCTCCTCGCGAGACAGTGAAGAGCTAGAGCAAGCAGCAAGGAGGCTT
 GCTAAGGCTGTGGGTTATGTTGGTGTGCTACTGTTGAATATCTCTACAGCATGGAGACTGGTGAATACT
 ATTTTCTGAACTTAATCCACGGTTGCAGGTTGAGCATCCAGTCAACGAGTGGATAGCTGAAGTAACTT
 GCCTGCAGCTCAAGTTGCAGTTGGAATGGGTATACCCCTTTGGCAGGTTCCAGAGATCAGACGTTTCTAT
 GGAATGGACAATGGAGGAGGCTATGACATTTGGAGGAAAACAGCAGCTCTTGCTACTCCATTTAACTTCG
 ATGAAGTGGATTCTCAATGGCCAAAGGGTCATTGTGTAGCAGTTAGGATAACCAGTGAGGATCCAGATGA
 CGGATTCAAGCCTACCGGTGGAAAAGTAAAGGAGATCAGTTTTAAAGCAAGCCAAATGTTTTGGCCTAT
 TTCTCTGTTAAGTCCGGTGGAGGCATTGATGAATTTGCTGATTCTCAGTTTGGACATGTTTTTGCATATG
 GAGTGTCTAGAGCAGCAGCAATAACCAACATGTCTCTTGCCTAAAAGAGATTCAAATTCGTGGAGAAAT
 TCATTCAAATGTTGATTACACAGTTGATCTCTTGAATGCCTCAGACTTCAAAGAAAACAGGATTACTACT
 GGCTGGCTGGATAACAGAATAGCAATGCGAGTCCAAGCTGAGAGACCTCCGTGGTATATTTTCAGTGGTTG
 GAGGAGCTCTATATAAAAACAATAACGAGCAACACAGACACTGTTTCTGAATATGTTAGCTATCTCGTCAA
 GGGTCAGATTCACCGAAGCATATATCCCTTGTCCATTCAACTGTTTCTTGAATATAGAGGAAAGCAAA
 TATACAATGAACTATAAAGGAGCGGACAGGGTAGCTACAGATTGCGAATGAATGGATCAGTTATTGAAG
 CAAATGTCAAACATTATGTGATGGTGGACTTTTAAATGCAGTTGGATGGAAACAGCCATGTAATTTATGC
 TGAAGAAGAGGCCGGTGGTACACGGCTTCTAATTTGATGGAAAGACATGCTTGTACAGAATGATCACGAT
 CCTTCAAGGTTATTAGCTGAGACACCCTGCAAACCTTCTTGGTTTCTTGGTTGCCGATGGTGTCTCATGTTG
 AAGCTGATGTACCATATGCGGAAGTTGAGGTTATGAAGATGTGCATGCCCTCTTGTACCTGCTGCTGG
 TGTCAATTAATGTTTTGTTGTCTGAGGGCCAGCCTATGCAGGCTGGTGTCTTATAGCAAGACTTGATCTT
 GATGACCCTTCTGCTGTGAAGAGAGCTGAGCCATTTAACGGATCTTTCCAGAAATGAGCCTTCCCTATTG
 CTGCTTCTGGCCAAGTTCAAAAAGATGTGCCACAAGCTTGAATGCTGCTCGGATGGTCTTGCAGGATA
 TGATCACCCGATCAACAAAGTTGTACAAGATCTGGTATCCTGTCTAGATGCTCCTGAGCTTCTTTCTTA
 CAATGGGAAGAGCTTATGTCTGTTTTAGCAACTAGACTTCCAAGGCTTCTTAAAGAGCGAGTTGGAGGGTA
 AATACAGTGAATATAAGTTAAATGTTGGCCATGGGAAGAGCAAGGATTTCCCTTCCAAGATGCTAAGAGA
 GATAATCGAGGAAAATCTTGCACATGGTTCTGAGAAGGAAATTTGCTACAAATGAGAGGCTTGTGTGAGCCT
 CTTATGAGCCTACTGAAGTCATATGAGGGTGGCAGAGAAAGCCATGCACACTTTATTGTGAAGTCCCTTT
 TCGAGGACTATCTCTCGGTTGAGGAACTATTAGTGATGGCATTGAGTCTGATGTGATTGAACGCCTGCG
 CCAACAACATAGTAAAGATCTCCAGAAGGTTGTAGACATTGTGTTGTCTCACCAGGGTGTGAGAAAACAAA
 ACTAAGCTGATACTAACACTCATGGAGAACTGGTCTATCCAAACCCTGCTGTCTACAAGGATCAGTTGA
 CTCGCTTTTCTCCCTCAATCACAAAAGATATTATAAGTTGGCCCTTAAAGCTAGCGAGCTTCTTGAACA
 AACCAAGCTTAGTGAGCTCCGCACAAGCATTGCAAGGAGCCTTTCCAGAACTTGAGATGTTTACTGAAGAA
 AGGACGGCCATTAGTGAGATCATGGGAGATTTAGTGACTGCCCACTGCCAGTTGAAGATGCACTGGTTT
 CTTTGTGTTGATTGTAGTGATCAAACCTTTCAGCAGAGGGTGTGAGACGTACATATCTCGATTATACCA

GCCTCATCTTGTCAAGGATAGTATCCAGCTGAAATATCAGGAATCTGGTGTATTGCTTTATGGGAATTC
GCTGAAGCGCATTTCAGAGAAGAGATTGGGTGCTATGGTTATTGTGAAGTCGTTAGAATCTGTATCAGCAG
CAATTGGAGCTGCACTAAAGGGTACATCACGCTATGCAAGCTCTGAGGGTAACATAATGCATATTGCTTT
ATTGGGTGCTGATAATCAAATGCATGGAAGCTGAAGACAGTGGTGATAACGATCAAGCTCAAGTCAGGATA
GACAACTTTCTGCGCACTGGAACAAAATACTGTCCAGCTGATCTCCGTGCTGCTGGTGTGAAGGTTA
TTAGTTGCATTGTTCAAAGGGATGGAGCACTCATGCCTATGCGCCATACCTTCTCTTGTGCGGATGAAAA
GCTTTGTTATGAGGAAGAGCCGGTTCTCCGGCATGTGGAGCCTCCTCTTTCTGCTCTTCTTGAGTTGGGT
AAGTTGAAAGTGAAAGGATACAATGAGGTGAAGTATACACCGTCACGTGATCGTCAGTGGAACATATACA
CACTTAGAAATACAGAGAACCCAAAATGTTGCACAGGGTGTTTTTCCGAACTCTTGTGAGGCAACCCGG
TGCTTCCAACAAATTCACATCAGGCAACATCAGTGATGTTGAAGTGGGAGGAGCTGAGGAATCTCTTCA
TTTACATCGAGCAGCATATTAAGATCGCTGATGACTGCTATAGAAGAGTTGGAGCTTCAAGGATTAGGA
CAGGTCATCTCATATGTTTTTGTGCATATTTGAAAGAGCAAAAGCTTCTTGATCTTGTCCCGTTTCAGG
GAAACAAAGTTGTGGATATTGGCCAAGATGAAGCTACTGCATGCTTGCTTCTGAAAGAAATGGCTCTACAG
ATACATGAACTTGTGGGTGCAAGGATGCATCATCTTTCTGTATGCCAATGGGAGGTGAAACTTAAGTTGG
ACAGCGATGGGCCTGCCAGTGGTACCTGGAGAGTTGTAACAACCAATGTTACTAGTCACACCTGCACTGT
GGATATCTACCGTGAGGTGCAAGATACAGAATCACAGAACTAGTGTACCACTCTGCTCCATCGTCATCT
GGTCTTTGTCATGGCGTTGCACTGAATACTCCATATCAGCCTTTGAGTGTATTGATCTGAAACGTTGCT
CCGCTAGAAATAACAGAACTACATACTGCTATGATTTTTCCGTTGGCATTGAAACTGCAGTGCAGAAGTC
ATGGTCTAACATTTCTAGTGACACTAACCGATGTTATGTTAAAGCGACGGAGCTGGTGTGCTCACAAG
AACGGGTGATGGGGCACTCCTGTAATTCCTATGGAGCGTCTGCTGGGCTCAATGACATTGGTATGGTAG
CTTGGATCTTGGACATGTCCACTCCTGAATATCCAATGGCAGGCAGATTGTTGTCATCGCAAATGATAT
TACTTTTAGAGCTGGATCGTTTTGGTCCAAGGGAAGATGCATTTTTTGAACCTGTTACCAACCTAGCTTGT
GAGAGGAAGCTTCTCTCATCTACTTGGCAGCAAACTCTGGTGTCTCGGATCGGCATAGCAGATGAAGTAA
AATCTTGCTTCCGTGTTGGATGGTCTGATGATGGCAGCCCTGAACGTGGGTTTTCAATATATTTATCTGAC
TGAAGAAGACCATGCTCGTATTAGCGCTTCTGTTATAGCGCACAAAGATGCAGCTTGATAATGGTGAAT
AGGTGGGTTATTGATTCTGTTGTAGGGAAGGAGGATGGGCTAGGTGTGGAGAACATACATGGAAGTGTCTG
CTATTGCCAGTGCCTATTCTAGGGCCTATGAGGAGACATTTACGCTTACATTTGTGACTGGAAGGACTGT
TGGAATAGAGCATATTTGCTCGACTTGGCATAAGGCTGATACAGCGTACTGACCAGCCATTATCCTA
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CCAAAATTATGGCGACAAACGGTGTGTCCATCTGCAGCTTTCAGATGACCTTGAAGGTGTATCTAATAT
ATTGAGGTGGCTCAGCTATGTTCTCGCAACATTTGGTGGACCTCTTCTTATTACAAAATCTTTGGACCCA
CCTGACAGACCCGTTGCTTACATCCCTGAGAATACATGCGATCCTCGTGCTGCCATCAGTGGCATTGATG
ATAGCCAAGGGAATGGTTGGGGGGCATGTTTCGACAAAGACAGTTTTTGTGGAGACATTTGAAGGATGGGC
GAAGTCAGTTGTTACTGGCAGAGCGAAACTCGGAGGGATTCCGGTGGGTGTTATAGCTGTGGAGACACAG
ACTATGATGCAGCTCATCCCTGCTGATCCAGGCCAGCTTGATTCCCATGAGCGATCTGTTCTCGTGCTG
GGCAAGTCTGGTTTTCCAGATTTCAGCTACTAAGACAGCGCAGGCAATGCTGGACTTCAACCGTGAAGGATT
ACCTCTGTTTCATCCTTGCTAACTGGAGAGGCTTCTCTGGTGGACAAAGAGATCTTTTTGAAGGAATCCTT
CAGGCTGGGTCAACAATTTGTTGAGAACCTTAGGACATACAATCAGCCTGCCTTTGTATATATCCCCAAGG
CTGCAGAGCTACGTGGAGGGGCTTGGGTGCTGATTGATAGCAAGATAAATCCAGATCGCATTGAGTTCTA
TGCTGAGAGGACTGCAAGGGCAATGTTCTCGAACCTCAAGGGTTGATCGAGATCAAGTTTCAGGTGAGAG
GAACTCCAAGAGTGCATGGGTAGGCTTGATCCAGAATTGATAAATCTGAAGGCAAAGCTCCAGGGAGTAA
AGCATGAAAATGGAAGTCTACCTGAGTCAGAATCCCTTCAGAAGAGCATAGAAGCCCGGAAGAAACAGTT
GTTGCCTTTGTATACTCAAATTCGGGTACGGTTTCGCTGAATTGCATGACACTTCCCTTAGAATGGCTGCT
AAGGGTGTGATTAAGAAGGTTGTAGACTGGGAAGATTCTAGGTGCTTCTTCTACAAGAGATTACGGAGGA
GGATATCCGAGGATGTTCTTGCGAAGGAAATTAGAGGTGTAAGTGGCAAGCAGTTTTCTCACCAATCGGC
AATCGAGCTGATCCAGAAATGGTACTTGGCCTCTAAGGGAGCTGAAACAGGAAGCACTGAATGGGATGAT
GACGATGCTTTTTGTTGCCTGGAGGGAAAAACCTGAAAACCTACCAGGAGTATATCAAAGAAGTCAAGGCTC
AAAGGGTATCTCAGTTGCTCTCAGATGTTGCAGACTCCAGTCCAGATCTAGAAGCCTTGGCACAGGGTCT
TTCTATGCTATTAGAGAAGATGGATCCCTCAAGGAGAGCACAGTTTTGTTGAGGAAGTCAAGAAAGTCTT
AAATGA

FIGURE 11B

>AAC39330_Triticum aestivum
 MGSTHLPIVGLNASTTPSLSTIRPVNSAGAAFQPSAPSRTS KKK
 SRRVQSLRDGGDGGVSDPNQSI RQGLAGIIDL PKEGTSAP EVDI SHGSEEPRGSYQMN
 GILNEAHNGRHASLSKVVEFCMALGGKTP IHSVLVANNGMAAAKFMRSVRTWANETFG
 SEKAIQLIAMATPEDMRINA EHIRIADQFVEVPGGTNNNNYANVQLIVEIAVRTGVSA
 VWPGWGHASENPEL PDALNANGIVFLGPPSSSMNALGDKVGSALIAQAAGVPTLPWSG
 SQVEI PLEVCLDSI PAEMYRKACVSTTEEALASCQMIGYPAMIKASWGGGGKIRKVN
 NDDDVRALFKQVQGEVPGSPI FIMRLASQSRHLEVQLLCDQYGNVAALHSRDCSVQRR
 HQKII EEGPVTVAPRET VKELEQAARRLAKAVGYVGAATVEYLYSMETGEYYFLELNP
 RLQVEHPVTEWIAEVNLPAAQVAVGMGIPLWQVPEIRR FYGMDNGGGYDIWRKTAALA
 TPFNFDEVDSQWPKGHCVAVRITSEDPDDGFKPTGGKVKEISFKSKPNVWAYFSVKSG
 GGIHEFADSQFGHVFAYGVSRAAAITNMSLALKEIQIRGEIHSNVDYTVDLLNASDFK
 ENRIHTGWLNDRIAMRVQAERPPWYISVVGALYKTITSN TDTVSEYVSYL VKGQIPP
 KHISLVHSTVSLNIEESKYTIETIRSGQGSYRLRMNGSVIEANVQTLCDGGLLMQLDG
 NSHVIYAE EEEAGGTRLLIDGKTCLLQNDHDP S RLLAETPCKLLRFLVADGAHVEADVP
 YAEVEVMKMCPLLSPAAGVINVLLSEGQPMQAGDLIARLDLDDPSAVKRAEPFNGSF
 PEMSLPIAASGQVHKRCATSLNAARMVLAGYDHPINKVVQDLVSCLDAPELPFLQWEE
 LMSVLATRLPRLKSELEGKYSEYKLVN VGHGKSKDFPSKMLREIIEENLAHGSEKEIA
 TNERLVEPLMSLLKSYEGGRESHAFIVKSLFEDYLSVEELFSDGIQSDVIERLRQOH
 SKDLQKVVDIVLSHQGVRNKT KLIITLMEKLVYPNPAVYKDQLTRFSSLNHKRYYKLA
 LKASELLEQTKLSELRTSIARSLSELEMFTEERTAISEIMGDLVTA PLPVEDALVSLF
 DCSDQTLQQRVIETYISRLYQPHLVKDSIQ LKYQESGVIALWEFAEAHSEKRLGAMVI
 VKSLESVSA AIGAALKGTSRYASSEGNIMHIALLGADNQM HGTEDSGDNDQAQVRIDK
 LSATLEQNTVTADLRAAGVKVISCIVQRD GALMPMRHTFLLSDEKLCYEEEPVLRHVE
 PPLSALLELGKLVKGYNEVKYTPSRDRQWNIYT LRNTENPKMLHRVVFRTLVRQPGA
 SNKFTSGNISDVEVGAAEESLSFTSSSILRSLMTAIEEELHAIRTG HSHMFLCILKE
 QKLLDLVPVSGNKVVDIGQDEATA CLLLKEMALQIHEL VGARMHHL SVCQWEVKKLKD
 SDGPASGTWRVVTNVT SHTCTVDIYREVEDTESQKLVYHSAPSSSGPLHGVALNTPY
 QPLSVIDLKRCSARNNR TTYCYDFPLAFETA VQKSWSNISSDTNRCYVKATELVFAHK
 NGSWGT PVI PMER PAGLNDIGMVAWILDMSTPEYPNGRQIVVIANDITFRAGSFGPRE
 DAFFETVTNLACERKLPLIYLAANS GARIGI ADEVKSCFRVGSDDGSPERGFQYIYL
 TEEDHARISASVIAHKMQLDNGEIRWVIDSVVGKEDGLGVENIHGSAAIASAYSRA YE
 ETFTLTFTVTGRTV GIGAYLARLGIRCIQRTDQPIILTGFSALNKLLGREVYSSHMQLG
 GPKIMATNGVVHLTVSDDLEGVSNILRWLSYVPANIGGPLPITKSLDPPDRPVAYIPE
 NTCDPRAAISGIDDSQ GKWLGGMFDKDSFVETFE GWAKSVVTGRAKLGIPVGVIAVE
 TQTMQLIPADPGQLDSHERSVPRAGQVWF PDSATKTAQAMLDFNREGLPLFILANWR
 GFSGGQDLDFEGILQAGSTIVENLR TYNQPAFVYIPKAAELRGGAWVIDSKINPDRI
 EFYAERTAKGNVLEPQGLIEIKFRSEELQECMGRLDPELINLKAKLQGVKHENGSLPE
 SESLQKSI EARKKQLLPLYTQI AVRFAELHDTSLRMAAKGVIKKVVDWEDSR SFFYKR
 LRRRI SEDVLAKEIRGVSGKQF SHQSAIELIQKWLASKGAETGSTEWDDDDAFVAWR
 ENPENYQEYIKELRAQRVSQ LLSDVADSSPDLEALPQGLSMLLEKMDPSRRAQFVEEV
 KKV LK

FIGURE 12A

>AY219174_Setaria italica (foxtail millet)

ATGTCGCAACTTGGATTAGCTGCAGCTGCCTCAAAGGCGCTGCCACTACTTCTAATCGCCATAGAACTT
CAGCTGGAACCTACATTCCCATCACCTGTATCATCGCGGCCCTCAAACCGAAGGAAAAGCCGCACTCGTTC
ACTTCGTGATGGAGGAGATGGGGTATCAGATGCCAAAAAGCACAAACCAGTCTGTCCGTCAAGGTCTTGCT
GGCATCATCGACCTCCCAAATGAGGCAACATCGGAAGTGGATATTTCTCATGGATCCGAGGATCCCAGGG
GGCCAACCGATTATATCAAATGAATGGGATTGTAAGTGAAGCACATAATGGCAGACATGCCTCAGTGT
CAAGGTTGTTGAATTTTGTGCGGCGCTAGGTGGCAAAACCAATTACAGTATACTAGTGGCCAACAAT
GGAATGGCAGCAGCAAAGTTCATGAGGAGTGTCCGGACATGGGCTAATGATACTTTTGGATCGGAGAAGG
CGATTCAGTTCATAGCTATGGCAACTCCAGAAGACATGAGGATAAATGCAGAACACATTAGAATTGCTGA
TCAATTTGTGGAGGTGCCTGGTGGAAACAAACAATAACAATATGCAAATGTTCAACTCATAGTGGAGGTA
GCAGAAAGAATAGGTGTTTCTGCTGTTTGGCCTGGTTGGGGTTCATGCTTCTGAGAATCCTGAACTTCCAG
ATGCATTGACCGCAAAGGAGTTGTTTCTTGGGCCACCTGCGGCATCAATGAATGCATTGGGAGATAA
GGTCCGTTTTCAGCTCTCATTGCTCAAGCAGCTGGGGTCCCGACCTTTTCGTGGAGTGGATCACATGTTGAA
GTTCCATTAGAGTGTCTTAGATGCGATACCTGAGGAAATGTATAGAAAAGCTTGTGTTACTACACAG
AAGAAGCTGTTGCGAGTTGTGAGGTGGTTGGTTATCCTGCCATGATTAAGGCATCCTGGGGAGGTGGTGG
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TGAGGAAGGCCAGTTACTGTTGCTCCTCGTGAGACAGTTAAAGCGCTTGAGCAGGCAGCAAGGAGGCTT
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ATTTTCTGGAGCTTAATCCCAGATTACAGGTCGAGCATCCAGTCACTGAGTGGATTGCTGAAGTAAATCT
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TTCTCAGTAAAGTCTGGTGGAGGCATTATGAATTTGTGATTCTCAGTTTGGGCATGTTTTGCATATG
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ACAATCAGCCTGCTTTTGTCTACATTCCTATGGCTGGAGAGCTGCGTGGAGGAGCTTGGGTTGTGGTTGA
TAGCAAAATAAATCCAGACCGAATTGAGTGTTATGCTGAGAGGACTGCTAAAGGCAATGTTCTGGAACCT
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TCAGAAGAGTATAGATGCTCGTACGAAACAGTTGTTGCCTTTATACACCAGATTGCAATACGGTTTGCT
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CACGTTCTTTCTTCTACAGAAGGCTACGGAGGAGGATCTCTGAAGATGTTCTTGCAAAAAGAAATAAGAGG
AATAGCTGGTGACCACTTCACTACCAATCAGCAGTTGAGCTGATCAAGGAATGGTACTTGGCTTCTCAA
GCCACAACAGGAAGCACTGAATGGGATGATGATGATGCTTTTGTGCTTGGAAAGGAGAATCCTGAAAACCT
ATAAGGGATATATCCAAGAGTTAAGGGCTCAAAGGTGCTCTCAGTCGCTCTCCGATCTTGCAGACTCCAG
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AAGTTCATTACAGGAAGTCAAGAAGGTCTGGGTTGA

FIGURE 12B

>AAO62902_Setaria italica (foxtail millet)
MSQLGLAAAASKALPLLPNRHRTSAGTTFFSPVSSRPSNRKSR
TRSLRDGGDGVSDAKKHNSVRQGLAGIIDLPNEATSEVDISHGSEDPRGPTDSYQMN
GIVSEAHNGRHASVSKVVEFCAALGGKTPIHLSILVANNGMAAAKFMRSVRTWANDTFG
SEKAIQLIAMATPEDMRINAHEHIRIADQFVEVPGGTNNNNYANVQLIVEVAERIGVSA
VWPGWGHASENPELDPALTAQGVVFLGPPAASMNALGDKVGSALIAQAAGVPTLSWSG
SHVEVPLECCLDAIPEEMYRKACVTTTTEEAVASCQVVGYPAMIKASWGGGGKIRKVH
NDDEVRALFKQVQGEVPGSPIFIMRLASQSRHLEVQLLCDQYGNVAALHSRDCSVQRR
HQKIIIEGPTVAVPRETVKALEQAARRLAKAVGYVGAATVEYLYSMETGEYYFLELNP
RLQVEHPVTEWIAEVNLPAAQVAVGMGIPLWQIPEIRRFDGM DYGGGYDIWRKTAALA
TPFNFDEVDSQWPKGHCVAVRITSEDPDDGFKPTGGKVKEISFKSKPNVWAYFSVKSG
GGIHEFVDSQFGHVFAAYGLSRSAITNMALALKEIQIRGEIHSNVDYTVDLLNASDFR
ENKIHTGWLDTRIAMRVQAERPPWYISVVGALYKTVTANAATVSDYVSYLTGQIIPP
KHISLVSSSTVNLNIEGSKYTVETVRTGHGYSYRLRMNDSAIEANVQSLCDGGLLMQLDG
NSHVIYAEAAAAGGTRLLIDGKTCLLQNDHDPKLLAETPCKLLRFLVADGAHVADAVP
YAEVEVMKMCMPLLSPASGVIHVMMSEGOALQAGDLIARLDLDDPSAVKRAEPFHGIF
PQMDLPVAASSQVHKRYAASWNAARMVLAGYEHNINEVVQDLVCCLDDPELPFLQWDE
LMSVLATRLPRNLKSELEDKMEYKLNIFYHGKNDKDFPSKLLRDIIEANLAYGSEKEKA
TNERLIEPLMSLLKSYEGGRESHAHFVVKSLFKEYLAVEELFSDGIQSDVIETLRHQH
SKDLQKVVDIVLSHQGVRNKA KLVTALMEKLVYPNPAAYRDLLVRFSSLNHKRYKLA
LKASELLEQTKLSELRSIARSLSDLGMHKGEMTIEDSMEDLVSAPLPVEDALISLFD
YSDPTVQQKVIETYISRLYQPLLVKDSIQVKFKESGAFALWEFSEGHVDTKNGQGTVL
GRTRWGAMVAVKSVESARTAIVAALKDSAQHASSEGNNMHIALLSAENENNISDDQAQ
HRMEKLNKILKDTSVANDLRAAGLKVISCI VQRDEARMPMRHTLLWSDEKSCYEEEQI
LRHVPEPLSMLLEMDKLVKGYNEMKYTPSRDRQWHIYTLRNTENPKMLHRVFFRTIV
RQPNAGNKFISAQIGDTEVGGPEESLSFTSNSILRALMTAIEEELHAI RTDHS MYL
CILKEQKLLDLIPFSGSTIVDVVQDEATACSLKSMALKIHELVG AQMHLSVCQWEV
KLKLYCDGPASGTWRVVTNTVTSHTCTVDIYREVEDTESQKLVYHSASPSASPLHGVA
LDNPYQPLSVIDLKHCSARNRRTTYCYDFPLAFETALQKSWQSNSSVSEGSSENSRSY
VKATELVFAEKHGSWGTPIIISMERPAGLNDIGMVAWILEMSTPEFPNGRQIIVIANDI
TFRAGSFGPREDAFFEAVTNLACERKLP LIYLAANS GARIGIADEVKSCFRVGSDEG
SPERGFQYIYLTDEDYARISLSVIAHKLQLDNGEIRWIIIDSVVGKEDGLGVENIHGSA
AIASAYSRA YEETFLLTFVTGRTVIGAYLARGIRCIQRLDQPIILTGFSALNKLLG
REVYSSHMQLGGPKIMATNGVVHLTVSDDLEGVSNILRWLSYVPANIGGPLPITKPLD
PPDRPVAYIPENTCDPRAAIRGVDDDSQGWLGGMFDKDSFVETFEGWAKTVVTGRAKL
GGIPVGVIAVETQTMQLIPADPGQLDSHERSVPRAGQVWFPDSATKTAQALLDFNRE
GLPLFILANWRGFGSGQRDLFEGILQAGSTIVENLRTYNQPAFVYIPMAGELRGGAWV
VVDKINPDRIECYAERTAKGNVLEPQGLIEIKFRSEELQDCMGR LDPGLINLKAKLQ
GAKLNGSLTDVESLQKSIDARTKQLLPLYTQIAIRFAELHDTSLRMAAKGVIKKVVD
WEESRSFFYRRLRRRI SEDVLAKEIRGIAGDHFTHQSAVELIKEWYLASQATTGSTEW
DDDDAFVAWKENPENYKGYIQELRAQKVSQSLSDLADSSSDLEAFSQGLSTLLDKMDP
SQRAKFIQEVKVLG

FIGURE 13A

>AY219175 _Setaria italica (foxtail millet)

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TCAGAAGAGTATAGATGCTCGTACGAAACAGTTGTTGCCTTTATACACCCAGATTGCAATACGGTTTGCT
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GCCACAACAGGAAGCACTGAATGGGATGATGATGATGCTTTTTGTTGCCTGGAAGGAGAATCCTGAAAACCT
ATAAGGGATATATCCAAGAGTTAAGGGCTCAAAAGGTGTCTCAGTCGCTCTCCGATCTTGACAGACTCCAG
TTCAGATCTAGAAGCATTCTCACAGGGTCTTTCCACATTATTAGATAAGATGGATCCCTCTCAGAGAGCC
AAGTTCATTGAGGAAGTCAAGAAGGTCTGGGTTGA

FIGURE 13B

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>AAO62903_Setaria italica (foxtail millet)
MSQLGLAAAASKALPLLPNRHRTSAGTTFPSPVSSRPSNRRKSR
TRSLRDGGDGVSDAKKHNSVRQGLAGIIDLPNEATSEVDISHGSEDPRGPTDSYQMN
GIVNEAHNGRHRASVSKVVEFCAALGGKTPIHLSILVANNGMAAAKFMRSVRTWANDTFG
SEKAIQLIAMATPEDMRINAHEHIRIADQFVEVPGGTNNNNYANVQLIVEVAERIGVSA
VWPGWGHASENPELDPALTAKGIVFLGPPAASMNALGDKVGSALIAQAAGVPTLSWSG
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TPFNFDEVDSQWPKGHCVAVRITSEDPDDGFKPTGGKVKEISFKSKPNVWAYFSVKSG
GGIHEFADSQFGHVFAYGLSRSAAITNMALALKEIQIRGEIHSNVDYTVDLLNASDFR
ENKIHTGWLDTRIAMRVQAERPPWYISVVGALYKTVTANAATVSDYVSYLTGQIIPP
KHISLVSSTVNLNIEGSKYTVETVRTGHGSYRLRMNDSAIEANVQSLCDGGLLMQLDG
NSHVIYAEAAAAGTRLLIDGKTCLLQNDHDPKLLAETPCKLLRFLVADGAHVADAVP
YAEVEVMKMCMPLLSPASGVIHVMMSEGOALQAGDLIARLDLDDPSAVKRAEPFHGIF
PQMDLPVAASSQVHKRYAASLNAARMVLAGYEHNINEVVQDLVCCLDDPELPFLOWDE
LMSVLATRLPRNLKSELEDKMEYKLNIFYHGKKNKDFPSKLLRDIIEANLAYGSEKEKA
TNERLIEPLMSLLKSYEGGRESHAHFVVKSLFKEYLAVEELFSDGIQSDVIETLRHQH
SKDLQKVVDIVLSHQGVRNKAKLVTALMEKLVYPNPAAYRDLLVRFSSLNHKRYKLA
LKASELLEQTKLSELRSIARSLSDLGMHKGEMTIEDSMEDLVSAPLPVEDALISLFD
YSDPTVQQKVIETYISRLYQPLLVKDSIQVKFKESGAFALWEFSEGHVDTKNGQGTVL
GRTRWGAMVAVKSVESARTAIVAALKDSAQHASSEGMMHIALLSAENENNISDDQAQ
HRMEKLNKILKDTSVANDLRAAGLKVISCIVQRDEARMPMRHTLLWSDEKSCYEEEQI
LRHVPEPLSMLLEMDKLVKGYNEMKYTPSRDRQWHIYTLRNTENPKMLHRVFFRTIV
RQPNAGNKFISAQIGDTEVGGPEESLSFTSNSILRALMTAIEEELHAI RTGHSHMYL
CILKEQKLLDLIPFSGSTIVDVGQDEATACSLKSMALKIHELVG AQMHLSVCQWEV
KLKLYCDGPASGTWRVVTTNVTSHCTCTIDIYREVEDTESQKLVYHSASPSASPLHGVA
LDNPHYQPLSVIDLKRC SARNNRTTYCYDFPLAFETALQKSWQSNSSVSEGENSRSY
VKATELVFAEKHGSWGTPIIISMERPAGLNDIGMVAWILEMSTPEFPNGRQII VIANDI
TFRAGSFGPREDAFFEAVTNLACERKLP LIYLAANS GARIGIAD EVKSCFRVGSDEG
SPERGFQYIYLTD EYARISLSVIAHKLQLDNGEIRWII DSVVGKEDGLGVENLHGSA
AIASAYSRA YEETF TLTFTVTGRTVIGAYLARLGIRCIQR LDQPIILTGFSALNKLLG
REVYSSHMQLGGPKIMATNGVVHLTVSDDLEGVSNILRWLSYVPANIGGPLPITKPLD
PPDRPVAYIPENTCDPRAAIRGVDDSQGKWLGGMFDKDSFVETFE GWAKTVVTGRAKL
GGIPVGVIAVETQTMMLIPADPGQLDSHERSVPRAGQVWFPDSATKTAQALLDFNRE
GLPLFILANWRGFSGGQDLFEGILQAGSTIVENLR TYNQPAFVYIPMAGELRGGAWV
VVDKINPDRIECYAERTAKGNVLEPQGLIEIKFRSEELQDCMGRLDPELINLKAKLQ
GAKLNGSLTDVESLQKSIDARTKQLLPLYTQIAIRFAELHDTSLRMAAKGVIKKVD
WEESRSFFYRRLRRRI SEDVLAKEIRGIAGDHFTHQSAVELIKEWY LASQATTGSTEW
DDDDAFVAWKENPENYKGYIQELRAQKVSQSLSLADSSSDLEAFSQGLSTLLDKMDP
SQRAKFIQEVKKVLG

```


FIGURE 14A

>AF294805_Setaria italica (foxtail millet)

ATGTCGCAACTTGGATTAGCTGCAGCTGCCTCAAAGGCGCTGCCACTACTTCCTAATCGCCATAGAACTT
 CAGCTGGAACTACATTCCCATCACCTGTATCATCGCGGCCCTCAAACCGAAGGAAAAGCCGCACTCGTTC
 ACTTCGTGATGGAGGAGATGGGGTATCAGATGCCAAAAGCACAACCAGTCTGTCCGTCAAGGTCTTGCT
 GGCATCATCGACCTCCCAAATGAGGCAACATCGGAAGTGGATATTTCTCATGGATCCGAGGATCCCAGGG
 GGCCAACCGATTATCATCAAATGAATGGGATTGTAAATGAAGCACATAATGGCAGACATGCCTCAGTGTC
 CAAGGTTGTTGAATTTTGTGCGGCGCTAGGTGGCAAACACCAATTCACAGTATACTAGTGGCCAACAAT
 GGAATGGCAGCAGCAAAGTTCATGAGGAGTGTCCGGACATGGGCTAATGATACTTTTGGATCGGAGAAGG
 CGATTAGCTCATAGCTATGGCAACTCCAGAAGACATGAGGATAAATGCAGAACACATTAGAATTGCTGA
 TCAATTTGTAGAGGTGCTGGTGGAAACAAAACAATAACAACATATGCAAATGTTCAACTCATAGTGGAGGTA
 GCAGAAAGAATAGGTGTTTCTGCTGTTTGGCCTGGTTGGGGTTCATGCTTCTGAGAATCCTGAACTTCCAG
 ATGCATTGACCGCAAAGGAATTGTTTTCTTGGGCCACCTGCGGCATCAATGAATGCATTGGGAGATAA
 GGTCCGTTTCTCATTGCTCAAGCAGCTGGGGTCCCGACCCTTTCGTGGAGTGGATCACATGTTGAA
 GTTCCATTAGAGTGTCTTAGATGCGATACCTGAGGAAATGTATAGAAAAGCTTGTGTTACTACCACAG
 AAGAAGCTGTTGCGAGTTGTGAGGTGGTTGGTTATCCTGCCATGATTAAGGCATCCTGGGGAGGTGGTGG
 TAAAGGAATAAGAAAGGTTTATAATGACGATGAGGTTAGAGCACTGTTTAAAGCAAGTACAAGGTGAAGTC
 CCTGGCTCCCAATATTTATCATGAGGCTTGCATCCAGAGTCGTATCTTGAAGTTTCAAGTTGCTTTGTG
 ATCAATATGGCAATGTGGCAGCACTTACAGTCTGTGATTGCGAGTGTGCAACGGCGCACCCAAAAGATTAT
 TGAGGAAGGCCAGTTACTGTTGCTCCTCGTGAGACAGTTAAAGCGCTTGAGCAGGCAGCAAGGAGGCTT
 GCTAAGGCTGTGGGTTATGTTGGTGTGCTACTGTTGAATACCTTTACAGCATGGAGACTGGGGAATACT
 ATTTTCTGGAGCTTAATCCCAGATTACAGGTGAGCATCCAGTCACTGAGTGGATTGCTGAAGTAAATCT
 TCCTGCAGCTCAAGTTGCAAGTTGGAATGGGCATACCTCTTTGGCAGATTCCAGAAATCAGACGTTTCTAT
 GGAATGGACTATGGAGGAGGATATGACATTTGGAGAAAACAGCAGCTCTTGCCACACCAATTTAATTTTG
 ATGAAGTAGATTCTCAATGGCCAAAGGGCCATTTGTGTAGCAGTTAGAATTAAGTACTAGCGAGGATCAGATGA
 TGGTTTTCAAACCTACTGGTGGGAAAGTGAAGGAGATAAGTTTTAAAGCAAGCCTAATGTTTGGGCCTAC
 TTCTCAGTAAAGTCTGGTGGAGGCATTATGAATTTGCTGATTCTCAGTTTGGGCATGTTTTTGCATATG
 GGCTCTCTAGATCAGCAGCAATAACGAACATGGCTCTTGCATTAAGAGATTCAAATTCGTGGAGAAAT
 TCATTCAAATGTTGATTACACAGTTGATCTCTTAAATGCTTCAAGCTTCAAGAGAAAATAAGATTCTACT
 GGCTGGCTTGATAACCAGAATAGCTATGCGTGTTCAGCTGAGAGGCCCCCATGGTATATTTTCAAGTGGTTG
 GAGGAGCTCTATATAAAAACAGTAACTGCCAATGCAGCCACTGTTTCTGATTATGTCAGTTATCTCACCAA
 GGGCCAGATTCCACCAAAGCATATATCCCTTGTGAGTTCAACAGTTAATCTGAATATCGAAGGGAGCAAA
 TACACAGTTGAACTGTAAGGACTGGACATGGTAGCTACAGATTACGAATGAATGATTGAGCAATTTGAAG
 CGAATGTACAATCTTTATGTGATGGAGGCCTCTTAATGCAGTTGGATGGAAATAGCCATGTAATTTACGC
 GGAAGAAGAAGCTGGTGGTACACGACTTCTGATTGATGGAAAGACATGCTTGTTACAGAATGATCATGAT
 CCATCAAAGTTATTAGCTGAGACACCCTGCAAACCTTCTTCCGTTCTTGGTTGCTGATGGTGTCTATGTTG
 ATGCTGATGTACCATATGCGGAAGTTGAGGTTATGAAAATGTGCATGCCTCTCTTGTGCGCTGCTTCTGG
 TGTCAATCATGTTATGATGTCTGAGGGCCAGGCATTGCAGGCTGGTGTATCTTATAGCAAGGCTGGATCTT
 GATGACCCTTCTGCTGTGAAAAGAGCTGAACCATTTTCAAGAAATATTTCCACAAATGGACCTTCCCTGTTG
 CTGCCCTAGCCAAGTACACAAAAGATATGCTGCAAGTTTGAATGCTGCTCGAATGGTCCCTTGCAGGATA
 CGAGCATAATATCAATGAAGTTGTACAAGATTTGGTATGCTGCCTGGATGATCCCGAGCTTCCCTTCTTA
 CAGTGGGATGAACTTATGTGAGTTCTAGCAACTAGGCTTCCAAGAAATCTTAAGAGTGAAGTTAGAGGATA
 AATACATGGAATACAAGTTGAACTTTTACCATGGGAAAACAAGGACTTCCCGTCCAAGCTGCTGAGAGA
 CATCATTGAGGCAAATCTTGCATATGGTTTCAAGAGAAGGAAAAGCTACGAATGAGAGGCTTATTGAGCCT
 CTTATGAGCCTACTTAAAGTCATATGAGGGTGGGAGAGAAAAGCCATGCTCATTGTTGTTGCAAGTCCCTTT
 TCAAGGAGTACCTTGTGTTGGAAGAACTTTTCAAGTATGGGATTGAGTCTGATGTGATTGAAACCTTGGC
 TCATCAGCACAGTAAAGACTTGCAGAAGGTTGTAGACATTTGTGTTGCTCACCAGGGTGTGAGGAACAAA
 GCTAAGCTTGTAAACAGCACTTATGGAAGGCTGGTTTATCCAAATCCTGCTGCTTACAGGGATCTGTTGG
 TTCGCTTTTCTTCACTCAATCATAAAAAGATATTATAAGTTGGCCCTTAAAGCAAGCGAACTTCTTGAACA
 AACTAAACTAAGTGAAGTCCGTGCAAGCATCGCAAGAAGCCTTTCTGATCTGGGGATGCATAAGGGAGAA
 ATGACTATTGAAGATAGCATGGAAGATTTAGTCTCTGCCCCATTACCTGTGCAAGATGCACCTATTTCTT
 TGTGTTGATTACAGTGTATCCAAGTGTTCAGCAGAAAGTGTGATCGAGACATACATATCTCGATTGTATCAGCC
 TCTTCTTGTGAAAGATAGCATCCAAGTGAATTTAAGGAATCTGGTGCCTTTGCTTTATGGGAATTTTCT

GAAGGGCATGTTGATACTAAAAATGGACAAGGGACCGTTCTTGGT CGAACCAAGATGGGGTGCCATGGTAG
CTGTCAAATCAGTTGAATCTGCACGAACAGCCATTGTAGCTGCATTAAAGGATTCGGCACAGCATGCCAG
CTCTGAGGGCAACATGATGCACATTGCCTTATTGAGTGTGCTGAAAATGAAAATAATATCAGTGATGATCAA
GCTCAACATAGGATGGAAAACTTAAACAAGATACTCAAGGATACTAGTGTGCGAAAATGATCTTCGAGCTG
CTGGTTTGAAGGTTATAAGTTGCATTGTTCAAAGAGATGAAGCACGCATGCCAATGCGCCACACATTACT
CTGGTCAGATGAAAAGAGTTGTTATGAGGAAGAGCAGATTCTTCGGCATGTGGAGCCTCCCCTCTCCATG
CTTCTTGAAATGGATAAGTTGAAAGTGAAAGGATACAATGAAATGAAGTATACTCCATCACGTGATCGTC
AATGGCATATCTACACACTAAGAAATACTGAAAACCCCAAATGTTGCATAGGGTATTTTTCCGAACACTAT
TGTCAGGCAACCCAATGCAGGCAACAAGTTTATATCAGCCCAAATGGCGACACTGAAGTAGGAGGCTCT
GAGGAATCTTTGTCATTTACATCTAATAGCATTTTAAGAGCCTTGATGACTGCTATTGAAGAATTAGAGC
TTCATGCAATTAGGACTGGTCATTCTCACATGTATTTGTGCATATTGAAAGAACAAAAGCTTCTTGATCT
CATTCCGTTTTTCAGGGAGCACAAATCGTCGATGTTGGCCAAGACGAAGCTACTGCTTGTTCACTTTTAAAA
TCAATGGCTTTGAAGATACACGAACTTGTGGTGACAGATGCATCATCTTTCTGTATGCCAGTGGGAGG
TGAAACTCAAGTTGTAAGTGGCCTGCCAGTGGCACCTGGAGAGTTGTAACACTACAAATGTTACTAG
TCACACTTGCACCGTTGATATCTACCGGGAAGTGGAAGATACTGAATCGCAGAAGTTAGTATAACCATTCA
GCTTCTCCGTGAGCTAGTCTTTGCATGGTGTGGCCCTGGATAATCCGTATCAACCTTTGAGTGTCTATTG
ATCTAAAACGCTGCTCTGCTAGGAACAACAGAACTACATATTGCTATGATTTTCCACTGGCATTGAAAC
TGCCCTGCAGAAGTCATGGCAGTCCAATGGCTCCAGTGTTCGAAGGCAGTGAAAATAGTAGGTCTTAT
GTGAAAGCAACAGAGCTGGTGTGCTGAAAACATGGGTCTGGGGCACTCCTATAATTTCCATGGAGC
GTCCCGCTGGGCTCAATGACATTGGCATGGTAGCTTGGATCTTAGAGATGTCCACTCCTGAATTTCCCAA
TGGCAGGCAGATTATTGTCATAGCAAATGATATTAATTTTCAGAGCTGGATCATTGGCCCAAGGGAAGAT
GCGTTTTTTGAAGCTGTCACGAACCTGGCCTGCGAGAGGAAGCTTCTCTTATATACTTGGCAGCAAACCT
CCGGTGCTAGGATTGGCATAGCCGATGAAGTGAAATCTTGCTTCCGTGTTGGGTGGTCCGATGAAGGCAG
CCCTGAACGGGGTTTTTCAGTACATTTATCTGACTGACGAAGACTATGCCCGTATTAGCTTGTCTGTTATA
GCACACAAGCTGCAGCTGGATAATGGTGAAATTAGGTGGATTATTGACTCTGTTGTGGGCAAGGAGGATG
GGCTTGGTGTGAGAATATACATGGAAGTGTGCTATTGCCAGTGTATTCTAGGGCATATGAGGAGAC
ATTTACACTTACATTTGACTGAGGCGGACTGTTGGAATAGGAGCATATCTTGCTCGGCTCGGTATACCGG
TGCATACAGCGTCTTGACCAGCCTATTATTTTAACTGGGTTTTCTGCCCTGAACAAGCTTCTTGGGCGGG
AAGTGTACAGCTCCACATGCAGTTGGGTGGTCTAAGATCATGGCGACCAATGGTGTGTTGCCACTTGAC
TGTTTCAGATGACCTTGAAGGTGTTTTCCAATATATTGAGGTGGCTCAGCTATGTTTCTGCCAACATTGGT
GGACCTCTTCTATTACAAAACCTTTGGACCCACCAGACAGACCTGTTGCATACATCCCTGAGAACACAT
GTGATCCGCGCGCAGCCATTCTGTTGGTGTAGATGACAGCCAAGGGAAATGGTTGGGTGGTATGTTTGACAA
AGACAGCTTTGTGAGACATTTGAAGGATGGGCGAAAACAGTGGTTACGGGCAGAGCAAAGCTTGGAGGA
ATTCCTGTTGGTGTCTAGCTGTGGAGACACAAAACCATGATGCAGCTTATCCCTGCTGATCCAGGCCAGC
TTGATTCCCATGAGCGATCTGTTTCTCGGGCTGGACAAGTGTGGTCCCAGATTCTGCAACCAAGACAGC
TCAGGCATTGTTGGACTTCAACCGTGAAGGATTGCCGCTGTTTCATCCTTGCTAACTGGAGAGGATTCTCT
GGTGGACAAAGAGATCTGTTTTGAAGGAATCTTCAGGCTGGGTCAACAATTGTTGAGAACCTTAGGACAT
ACAATCAGCCTGCTTTTGTCTACATTCCTATGGCTGGAGAGCTGCGTGGAGGAGCTTGGGTTGTGGTTGA
TAGCAAAATAAATCCAGACCGAATTGAGTGTATGCTGAGAGGACTGCTAAAGGCAATGTTCTGGAACCT
CAAGGTTAATTGAAATCAAATTCAGATCAGAGGAGCTCCAAGACTGTATGGGTAGGCTTGACCCAGAGT
TGATAAATCTGAAAGCAAACTCCAAGGTGCAAAGCTTGGAAATGGAAGCCTAACAGATGTAGAATCCCT
TCAGAAGAGTATAGATGCTCGTACGAAAACAGTTGTTGCCTTTATACACCAGATTGCAATACGGTTTGCT
GAATTGCATGATACTTCCCTCAGAATGGCAGCTAAAGGTGTGATTAAGAAAGTTGTAGATTGGGAAGAAT
TACGTTCTTTCTTACAGAAGGCTACGGAGGAGGATCTCTGAAGATGTTCTTGCAAAAAGAAATAAGAGG
AATAGCTGGTGACCACTTCACTCACCAATCAGCAGTTGAGCTGATCAAGGAATGGTACTTGGCTTCTCAA
GCCACAACAGGAAGCACTGAATGGGATGATGATGCTTTTTGTTGCCCTGGAAGGAGAATCCTGAAAACCT
ATAAGGGATATATCCAAGAGTTAAGGGCTCAAAGGTGTCTCAGTCGCTCTCCGATCTTGACAGACTCCAG
TTCAGATCTAGAAGCATTCTCACAGGGTCTTTCCACATTATTAGATAAGATGGATCCCTCTCAGAGAGCC
AAGTTCATTAGGAAGTCAAGAAGGTCTGGGTTGA

FIGURE 14B

>AAL02056_Setaria italica (foxtail millet)
MSQLGLAAAASKALPLLPNRHRTSAGTTFPSPVSSRPSNRKSR
TRSLRDGGDGVSDAKKHNSVRQGLAGIIDLPNEATSEVDISHGSEDPRGPTDSYQMN
GIVNEAHNGRHASVSKVVEFCAALGGKTPIHSLVANNGMAAAKFMRSVRTWANDTFG
SEKAIQLIAMATPEDMRINAEHIRIADQFVEVPGGTNNNNYANVQLIVEVAERIGVSA
VWPGWGHASENPELDPALTAKGIVFLGPPAASMNALGDKVGSALIAQAAGVPTLSWSG
SHVEVPLECCLDAIPEEMYRKACVTTEEEAVASCQVVGYPAMIKASWGGGGKIRKVVH
NDDEVRALFKQVQGEVPGSPIFIMRLASQSRHLEVQLLCDQYGNVAALHSRDCSVQRR
HQKIEEGPVTVAPRETVKALEQAARRLAKAVGYVGAATVEYLYSMETGEYYFLELNP
RLQVEHPVTEWIAEVNLPAAQVAVGMGIPLWQIPEIRRFYGM DYGGGYDIWRKTAALA
TPFNDFEVD SQWPKGHCVAVRITSEDPDDGFKPTGGKVKEISFKSKPNVWAYFSVKS
GGIHEFAD SQFGHV FAYGLSRSAATNMALALKEIQIRGEIHSNVDYTVDLLNASDFR
ENKIHTGWL DTRI AMRVQAERPPWYISVVGALYKTVTANAATVSDYVSYLTGQIIPP
KHISLVSS TVNLNIEGSKYTVETVRTGHGSRRLMNSDAIEANVQSLCDGGLLMQLD
NSHVIYAE EEEAGGTRLLIDGKTCLLQNDHDP SKLLAETPCKLLRFLVADGAHV DADVP
YAEVEVMKMC PMLS PASGVIHVMMSE GQALQAGDLIARLDLDDPSAVKRAEPFHGIF
PQMDLPVA ASSQVHKRYAASLNAARMVLAGYEHNINEVVQDLVCCLDDPELPFLQWDE
LMSVLATRLPRNLKSELEDK YMEYKLN FYH GKND FPSKLLRDIIEANL AYGSEKEKA
TNERLIEPLMSLLKSYEGGRESHAHFVVKSLFKEYLAVEELFSDGIQSDVIETLRHQH
SKDLQKVVDI VLSHQGV RNKAKLVTALMEKLVYPNPAAYRDL LVRFSSLNHKRYYKLA
LKASELLEQT KLS ELRAS IARSLSD LGMHKGEMTIEDSMEDLVSAPLPVEDALISLFD
YSDPTVQQKVIETYISRLYQPLLVKDSIQVKFKESGAFALWEFSEGHVDTKNGQGTVL
GRTRWGAMVA VKSVESARTAI VAALKDSAQHASSEGNNMHIALLSAENENNISDDQAO
HRMEKLNKILKDT SVANDLRAAGLKVISCI VQRDEARMPMRHTLLWSDEKSCYEEEQI
LRHVEPPLSMLLEMDKLVKGYNEMKYTPSRDRQWHIYTLRNTENPKMLHRVFFRTIV
RQPNAGNKFI SAQIGDTEVGGPEESLSFTSNSILRALMTAIEEELHAI RTGHSHMYL
CILKEQKLLDLI PFSGSTIVDVGQDEATACSLKSMALKIHEL VGAQMHHLSVCQWEV
KLKLYCDGPASGTWRVVTTNVT SHTCTVDIYREVEDTESQKLVYHSASPSASPLHGVA
LDNPYQPLSVIDLKRCSARNNRTTYCYDFPLAFETALQKSWQSNSSVSEGSNSRSY
VKATELVFAEKHGSWGTPIIISMERPAGLNDIGMVAVILEMSTPEFPNGRQIIVIANDI
TFRAGSFGPREDAFFEAVTNLACERKLP LIYLAANS GARIGIAD EVKSCFRVGSDEG
SPERGFQYIYLTD EYARISLSVIAHKLQLDNGEIRWIIDS SVVGKEDGLGVENIHGSA
AIASAYSRA YEETF TLTFTVTGRTVIGAYLARLGIRCIQR LDQPIILTGFSALNKLLG
REYVSSHMQ LGGPKIMATNGVVHLTVSDDLEGVSNILRWLSYVPANIGGPLPITKPLD
PPDRPVAYI PENTCDPRAAIRGVDDSQGKWLGGMFDKDSFVETFE GWAKTVVTGRAKL
GGIPVGVIAVETQ TMMQLI PADPGQLDSHERSVPRAGQVWF PDSATKTAQALLDFNRE
GLPLFILANWRGFSGGQ RDLFEGILQAGSTIVENLR TYNQPAFVYI PMAGELRGGAWV
VVDSKINPDRIECYAERTAKGNVLEPQGLIEIKFRSEELQDCMGR LDPELINLKAKLQ
GAKLGNGLSLTDVESLQKSIDARTKQLLPLYTQIAIRFAELHDTSLRMAAKGVIKKVV
WEELRSFFYRRLRRRI SEDVLAKEIRGIAGDHFTHQSAVELIKEWY LASQATTGSTEW
DDDDAFVAWKENPENYKGYIQELRAQKVSQSLSDLADSSDLEAFSQGLSTLLDKMDP
SQRAKFIQEVK KVLG

FIGURE 15A

>AJ310767 *Alopecurus myosuroides* (black-grass)

ATGGGATCCACACATCTGCCCATTTGTCGGGTTTAAATGCATCCACAACACCATCGCTATCCACTCTTCGCC
 AGATAAACTCAGCTGCTGCTGCATTCCAATCTTCGTCCCCTTCAAGGTCATCCAAGAAGAAAAGCCGACG
 TGTTAAGTCAATAAGGGATGATGGCGATGGAAGCGTGCCAGACCCTGCAGGCCATGGCCAGTCTATTTCG
 CAAGGTCCTCGCTGGCATCATCGACCTCCCAAAGGAGGGCGCATCAGCTCCAGATGTGGACATTTTACATG
 GGTCTGAAGACCACAAGGCCTCCTACCAAATGAATGGGATACTGAATGAATCACATAACGGGAGGCACGC
 CTCTCTGTCTAAAGTTTATGAATTTTGCACGGAATTTGGTGGAAAAACCAATTCACAGTGTATTAGTC
 GCCAACAAATGGAATGCGAGCAGCTAAGTTTCATGCGGAGTGTCCGGACATGGGCTAATGATACATTTGGGT
 CAGAGAAGGCGATTCAGTTGATAGCTATGGCAACTCCGGAAGACATGAGAATAAATGCAGAGCACATTTAG
 AATTGCTGATCAGTTTGTGTAAGTACCTGGTGGAAACAAACAATAACAATATGCAAATGTCCAACCTATA
 GTGGAGATAGCAGAGAGAACTGGTGTCTCCGCCGTTTGGCCTGGTTGGGGCCATGCATCTGAGAATCCTG
 AACTTCCAGATGCACCTAACTGCAAAAGGAATTTGTTTTTCTTGGGCCACCAGCATCATCAATGAACGCACT
 AGGCGACAAGGTTGGTTTCTCAGCTCTCATTGCTCAAGCAGCAGGGGTTCCCACTCTTGCTTGGAGTGGATCA
 CATGTGGAAATTCATTAGAACTTTGTTTGGACTCGATACTGAGGAGATGTATAGGAAAGCCTGTGTTA
 CAACCGCTGATGAAGCAGTTGCAAGTTGTGATGATTGGTTACCCTGCCATGATCAAGGCATCCTGGGG
 TGGTGGTGGTAAAGGGATTAGAAAGGTTAATAATGATGACGAGGTGAAAGCACTGTTTAAGCAAGTACAG
 GGTGAAGTTCCTGGCTCCCCGATATTTATCATGAGACTTGCATCTCAGAGTCGTATCTTGAAGTCCAGC
 TGCTTTGTGATGAATATGGCAATGTAGCAGCACTTACAGTCGTGATTGCAGTGTGCAACGACGACACCA
 AAAGATTATCGAGGAAGGACCAGTTACTGTTGCTCCTCGTGAAACAGTGAAAGAGCTAGAGCAAGCAGCA
 AGGAGGCTTGCTAAGGCCGTTGGGTTACGTGGTGTGCTACTGTTGAATATCTCTACAGCATGGAGACTG
 GTGAATACTATTTTCTGGAGCTTAATCCACGGTTGCAGGTTGAGCACCCAGTCACCGAGTCGATAGCTGA
 AGTAAATTTGCCTGCAGCCCAAGTTGCAGTTGGGATGGGTATAACCCCTTTGGCAGATTCAGAGATCAGA
 CGTTTCTACGGAATGGCAATGGAGGAGGCTATGATATTTGGAGGAAAAACAGCAGCTCTCGCTACTCCAT
 TCAACTTTGATGAAGTAGATTCTCAATGGCCGAAGGTCATTGTGTGGCAGTTAGGATAACCAGTGAGAA
 TCCAGATGATGGATTCAAGCCTACTGGTGGAAAAGTAAAGGAGATAAGTTTAAAAAGTAAAGCAAATGTC
 TGGGGATATTTCTCAGTTAAGTCTGGTGGAGGCATTTCATGAATTTGCGGATTTCTCAGTTTGGACAGGTTT
 TTGCCTATGGAGAGACTAGATCAGCAGCAATAACCAGCATGTCTTTCGACTAAAAGAGATTCAAATTCG
 TGGAGAAATTCATACAAACGTTGATTACACGGTTGATCTCTTGAATGCCCCAGACTTCAGAGAAAACACG
 ATCCATAACCGGTTGGCTGGATACCAGAATAGCTATGCGTGTTCAGCTGAGAGGCCCTCCCTGGTATATTT
 CAGTGGTTGGAGGAGCTCTATATAAAAACAATAACCACCAATGCGGAGACCGTTTCTGAATATGTTAGCTA
 TCTCATCAAGGTCAGATTCACCAAAGCACATATCCCTTGTCCATTCAACTATTTCTTTGAATATAGAG
 GAAAGCAAATATACAATTGAGATTGTGAGGAGTGGACAGGGTAGCTACAGATTGAGACTGAATGGATCAC
 TTATTGAAGCCAATGTACAAACATTATGTGATGGAGGCCTTTTAAATGCAGCTGGATGGAAATAGCCATGT
 TATTTATGCTGAAGAAGAAGCGGGTGGTACACGGCTTCTTATTGATGGAAAAACATGCTTGCTACAGAAT
 GACCATGATCCGTCAAGGTTATTAGCTGAGACACCCTGCAAACCTTCTTCGTTTCTTGATTGCCGATGGTG
 CTCATGTTGATGCTGATGTACCATAACCGGAAGTTGAGGTTATGAAGATGTGCATGCCCTCTTGTTCGCC
 TGCTGCTGGTGTCAATTAATGTTTTGTTGTCTGAGGGCCAGGCGATGCAGGCTGGTGTCTTTATAGCGAGA
 CTTGATCTCGATGACCCTTCTGCTGTGAAGAGAGCCGAGCCATTTGAAGGATCTTTTCCAGAAATGAGCC
 TTCCTATTGCTGCTTCTGGCCAAGTTCAAAAAGATGTGCTGCAAGTTTGAACGCTGCTCGAATGGTCTT
 TGCAGGATATGACCATGCGGCCAACAAAGTTGTGCAAGATTTGGTATGGTGCCTTGATACACCTGCTCTT
 CCTTTCTACAATGGGAAGAGCTTATGTCTGTTTTAGCAACTAGACTTCCAAGACGCTTTAAGAGCGAGT
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 GCTTAGAGAGACAATCGAGGAAAATCTTGCATGTGTTTTCCGAGAAGGAAATGGTGACAATTGAGAGGCTT
 GTTGACCCCTCTGATGAGCCTGCTGAAGTCATACGAGGGTGGGAGAGAAAGCCATGCCACTTTTATTGTCA
 AGTCCCTTTTTGAGGAGTATCTCTCGGTTGAGGAACATTTCAGTGATGGCATTTCAGTCTGAGCTGATTGA
 ACGCTGCGCCTACAATATAGTAAAGACCTCCAGAAGGTTGTAGACATTGTTTTGTCTCACCAGGGTGTG
 AGAAACAAAACAAAGCTGATACTCGCGCTCATGGAGAACTGGTCTATCCAAACCCTGCTGCCTACAGAG
 ATCAGTTGATTGCTTTTTCTCCCTCAACCATAAAAGATATTTATAAGTTGGCTCTTAAAGCTAGTGAACCT
 TCTTGAACAAAACCAAGCTCAGCGAACCCTCGCACAAAGCATGCAAGGAACCTTTCAGCGCTGGATATGTTT
 ACCGAGGAAAAGGCAGATTTCTCCTTGAAGACAGAAAATTTGGCCATTAATGAGAGCATGGGAGATTTAG
 TCACTGCCCCACTGCCAGTTGAAGATGCACTTGTCTTCTTTGTTTGTGATTGTACTGATCAAACCTTTCAGCA
 GAGAGTATTGAGACATACATATCTCGATTATACCAGCCTCAACTTGTGAAGGATAGCATCCAGCTGAAA
 TATCAGGATTCCTGGTGTATTGCTTTATGGGAATTCCTGAAGGAAATCATGAGAAGAGATTGGGTGCTA
 TGTTTATCCTGAAGTCACTAGAATCTGTGTCAACAGCCATTGGAGCTGCTCTAAAGGATGCATCACATTA

TGCAAGCTCTGCGGGCAACACGGTGCATATTGCTTTGTTGGATGCTGATACCCAACCTGAATACAACCTGAA
GATAGTGGTGATAATGACCAAGCTCAAGACAAGATGGATAAACTTTCTTTTGTACTGAAACAAGATGTTG
TCATGGCTGATCTACGTGCTGCTGATGTCAAGGTTGTTAGTTGCATTGTTCAAAGAGATGGAGCAATCAT
GCCTATGCGCCGTACCTTCTCTTGTGAGAGGAAAACTTTGTTACGAGGAAGAGCCGATTCTTCGGCAT
GTGGAGCCTCCACTTTCTGCACTTCTTGAGTTGGATAAAATTGAAAGTGAAAGGATACAATGAGATGAAGT
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CAGGGTATTTTCCGAACACTTGTGAGACAACCCAGTGCAGGCAACAGGTTTACATCAGACCATATCACT
GATGTTGAAGTAGGACACGCAGAGGAACCTCTTTCATTTACTTCAAGCAGCATATTAATAATCGTTGAAGA
TTGCTAAAGAAGAATTGGAGCTTACGCGATCAGGACTGGCCATTCTCATATGTACTTGTGCATATTGAA
AGAGCAAAAGCTTCTTGACCTTGTTCCTGTTTTCAGGGAACTGTTGTGGATGTTGGTCAAGATGAAGT
ACTGCATGCTCTCTTTTGAAGAAATGGCTTTAAAGATACATGAACTTGTGGTGAAGAATGCATCATC
TTTCTGTATGCCAGTGGGAAGTGAACCTTAAGTTGGTGAGCGATGGGCCTGCCAGTGGTAGCTGGAGAGT
TGTAACAACCAATGTTACTGGTCAACCTGCACTGTGGATATCTACCGGGAGGTGGAAGATACAGAATCA
CAGAACTAGTATACCACTCCACCGCATTGTGATCTGGTCTTTGTCATGGTGTGCACTGAATACTTCGT
ATCAGCCTTTGAGTGTATTGATTTAAAACGTTGCTCTGCCAGGAACAACAAAACACTACATACTGCTATGA
TTTTCCATTGACATTTGAAGCTGCAGTGCAGAAGTCGTGGTCTAACATTTCCAGTGAAAAACAACCAATGT
TATGTTAAAGCGACAGAGCTTGTGTTTGTGAAAAGAATGGGTGCTGGGGCACTCCTATAATTCCTATGC
AGCGTGCTGCTGGGCTGAATGACATTTGGTATGGTAGCCTGGATCTTGGACATGTCCACTCCTGAATTTCC
CAGCGGCAGACAGATCATTGTTATCGCAAATGATATTACATTTAGAGCTGGATCATTGGCCCAAGGGAA
GATGCATTTTTTGAAGCTGTAACCAACCTGGCTTGTGAGAAGAAGCTTCCACTTATCTACTTGGCTGCAA
ACTCTGGTGCTCGGATTGGCATTGCTGATGAAGTAAATCTTGCTTCCGTGTTGGATGGACTGATGATAG
CAGCCCTGAACGTGGATTTAGGTACATTTATATGACTGACGAAGACCATGATCGTATTGGCTCTTCAGTT
ATAGCACACAAGATGCAGCTAGATAGTGGCGAGATCAGGTGGGTTATTGATTCTGTTGTGGGAAAAGAGG
ATGGATAGGTGTGGAGAACATACATGGAAGTGTGCTATTGCCAGTGCCTATCTAGGGCGTACGAGGA
GACATTTACATTCATTGTTACTGGACGAACTGTTGGAATCGGAGCCTATCTTGCTCGACTTGGCATA
CGGTGCATACAGCGTATTGACCAGCCATTATTTTTGACCGGGTTTTCTGCCCTGAACAAGCTTCTTGGGC
GGGAGGTGTACAGCTCCACATGCAGTTGGTGGTCCCAAATCATGGCGACGAATGGTGTTCATCT
GACTGTTCCAGATGACCTTGAAGGTGTTTTCTAATATATTGAGGTGGCTCAGCTATGTTCCCTGCAACATT
GGTGGACCTCTTCTATTACAAAATCTTTGGACCCAATAGACAGACCCGTTGCATACATCCCTGAGAATA
CATGTGATCCTCGTGCAGCCATCAGTGGCATTGATGACAGCCAAGGGAAATGGTTGGGTGGCATGTTTGA
CAAAGACAGTTTTTGTGGAGACATTTGAAGGATGGGCGAAGACAGTAGTTACTGGCAGAGCAAAACTTGGGA
GGGATTCTGTTGGTGTATAGCTGTGGAGACACAGACCATGATGCAGCTCGTCCCCGCTGATCCAGGCC
AGCCTGATTTCCACGAGCGGTCTGTTCTCGTGTGGGCAAGTTTGGTTTTCCAGATTTCTGCTACCAAGAC
AGCGCAGGCGATGTTGGACTTCAACCGTGAAGGATTACCTCTGTTTACTACTTGTAACTGGAGAGGCTTC
TCTGGAGGGCAAAGAGATCTTTTTGAAGGAATTTCTGCAGGCTGGGTCAACAATTTGTTGAGAACCCTTAGGA
CATAAATCAGCCTGCCTTTGTATATATCCCCAAGGCTGCAGAGCTACGTGGAGGAGCCTGGGTCTGTGAT
TGATAGCAAGATAAACCAGATCGCATCGAGTGTATGCTGAGAGGACTGCAAAGGGTAATGTTCTCGAA
CCTCAAGGGTTGATTGAGATCAAGTTTCAAGTGCAGAGGAACTCAAAGAATGCATGGGTAGGCTTGATCCAG
AATTGATAGATCTGAAAGCAAGACTCCAGGGAGCAAATGGAAGCCTATCTGATGGAGAATCCCTTCAGAA
GAGCATAGAAGCTCGGAAGAAACAGTTGCTGCCTCTGTACACCCAAATCGCGGTACGTTTTGCGGAATTG
CACGACACTTCCCTTAGAATGGCTGCTAAAGGTGTGATCAGGAAAGTTGTAGACTGGGAAGACTCTCGGT
CTTCTTCTACAAGAGATTACGGAGGAGGCTATCCGAGGACGTTCTGGCAAAGGAGATTAGAGGTGTAAT
TGGTGAAGAAGTTTTCTCACAATCAGCGATCGAGCTGATCAAGAAATGGTACTTGGCTTCTGAGGCAGCT
GCAGCAGGAAGCACCGACTGGGATGACGACGATCTTTTGTGCGCTGGAGGGAGAACCCTGAAAACCTATA
AGGAGTATATCAAAGAGCTTAGGGCTCAAAGGGTATCTCGGTTGCTCTCAGATGTTGCAGGCTCCAGTTC
GGATTTACAAGCCTTGCCGCAGGGTCTTTCCATGCTACTAGATAAGATGGATCCCTCTAAGAGAGCACAG
TTTATCGAGGAGGTCATGAAGGTCCTGAAATGA

FIGURE 15B

>CAC84161 *Alopecurus myosuroides* (black-grass)
 MGSTHLPIVGFNASTTPSLSTLRQINSAAAAFQSSSPSRSSKKSRRVKSIRDDGDGSPDPAGHGQSIR
 QGLAGIIDLPKEGASAPDVIDISHGSEDHKASYQMNGILNESHNGRHASLSKVYEFCTELGGKTPIHSLV
 ANNGMAAAKFMRSVRTWANDTFGSEKAIQLIAMATPEDMRINAEHIRIADQFVEVPGGTNNNNYANVQLI
 VEIAERTGVS AVWPGWGHASENPELDPALTAKGIVFLGPPASSMNALGDKVGSALIAQAAGVPTLAWSGS
 HVEI PLELCLDSIPEEMYRKACVTTADEAVASCQMIGYPAMIKASWGGGGKIRKVNNDDEVKALFKQVQ
 GEVPGSPIFIMRLASQSRHLEVQLLCDEYGNVAALHSRDCSVQRRHQKIEEGPVTVAPRETVKELEQAA
 RRLAKAVGYVGAATVEYLYSMETGEYYFLELNPRQLQVEHPVTESIAEVNLPAAQVAVGMGIPLWQIPEIR
 RFGYMDNNGGGYDIWRKTAALATPFNFDEVDSQWPKGHCVAVRITSENPDGFKPTGGKVKEISFKSKPNV
 WGYFSVKSGGGIHEFADSQFGHVFAYGETRSAAITSMMLALKEIQIRGEIHTNVDYTVDLLNAPDFRENT
 IHTGWLDRIAMRVQAERPPWYISVVGALYKTITTTNAETVSEYVSYLKQGIPPKHISLVHSTISLNI
 ESKYTIETVRSQGGSYRLRLNGLIEANVQTLCDGGLLMLQLDGNSHVIYAEAAAAGGTRLLIDGKTCLLQN
 DHDPSRLLAETPCKLLRFLIADGAHVADVPYAEVEVMKCMPLLSPAAGVINVLLSEGOAMQAGDLIAR
 LDLDPPSAVKRAEPFEGSFPEMSLPIAASGVQVHKRCAASLNAARMVLAGYDHAANKVVQDLVWCLDTPAL
 PFLQWEELMSVLATRLPRRLKSELEGKYNEYKLNVDHVKIKDFPTEMLRETIEENLACVSEKEMVTIERL
 VDPLMSLLKSYEGGRESHAFIVKSLFEEYLSVEELFSDGIQSDVIERLRLQYSKDLQKVVDIVLSHQGV
 RNKTKLILALMEKLVYPNPAAYRDQLIRFSSLNHKRYKALALKASELLEQTKLSELRTSIARNLSALDMF
 TEEKADFSLQDRKLAINESMGDLVTAPLPVEDALVSLFDCTDQTLQQRVIQTYISRLYQPQLVKDSIQLK
 YQDSGVIALWEFTEGNHEKRLGAMVILKSLESVSTAIGAALKDASHYASSAGNTVHIALLDADTQLNTE
 DSGDNDQAQDKMDKLSFVLKQDVVMADLRAADVQVVCIVQRDGAIMPMMRRTFLLSEEKLCYEEEPILRH
 VEPPLSALLELDKLVKGYNEMKYTPSRDRQWHIYTLRNTENPKMLHRVFFRFLVLRQPSAGNRFTSDHIT
 DVEVGHAEEPLSFTSSILKSLKIAKEEELHAIRTGHS MYLCILKEQKLLDLVPVSGNTVVDVQDEA
 TACSLLKEMALKIHELVGARMHLSVCQWEVKLKLVS DGPASGSRVVTNTVTGHTCTVDIYREVEDTES
 QKLVYHSTALSSGPLHGVALNTSYQPLSVIDLKRC SARNNKTTYCYDFPLTFEAAVQKSWSNISSENNQC
 YVKATELVFAEKNGSWGTPPIIPMORAAGLNDIGMVAWILDMSTPEFPSSGRQIIVIANDITFRAGSFGPRE
 DAFFEAVTNLACEKKLPLIYLAANSGARIGIADEVKSCFRVGTDDSSPERGFRYIYMTDEDHDRIGSSV
 IAHKMQLDSGEIRWVIDSVVGKEDGLGVENIHGSAAIASAYS RAYEETFLLTFVTGRTVIGIAYLARLGI
 RCIQRIDQPIILTGFSALNKL GREVYSSHMLGGPKIMATNGVVHLTVPDDLEGVSNILRWLSYVPANI
 GGPLPITKSLDPIDRPVAYIPENTCDPRAAISGIDDSQGWLGGMFDKDSFVETFEGWAKTVVTGRAKLG
 GIPVGVIAVETQTMQLVPADPGQPD SHERSVPRAGQVWF PDSATKTAQAMLDNFNREGLPLFILANWRGF
 SGGQRDLFEGILQAGSTIVENLR TYNQPAFVYIPKAAELRGGAWVIDSKINPDRIECYAERTAKGNVLE
 PQGLIEIKFRSEELKECMGRLDPELIDLKARLQGANGLSDGESLQKSI EARKKQLLPLYTQI AVRFAEL
 HDTSLRMAAKGVIRKVVWDWEDSRSFYKRLRRRLS EDVLAKEIRGVIGEKFPKSAIELIKKWYLASEAA
 AAGSTDWDDDDAFVAWRENPENYKEYIKELRAQRVSRLLSDVAGSSDLQALPQGLSMLLDKMDPSKRAQ
 FIEEVMKVLK

FIGURE 16A

>EU660897_Aegilops tauschii (jointed goatgrass)

ATGGGATCCACACATTTGCCCATTTGTCGGCCTTAATGCCTCGACAACACCATCGCTATCCACTATTCGCCCGGTAAA
TTCAGCCGGTGTGCATTCCAACCATCTGCCCTTCTAGAACCCTCCAAGAAGAAAAGTCGTGCTGTTTCAGTCATTAA
GGGATGGAGGCGATGGAGGCGTGTGACACCTAACAGTCTATTTCGCCAAGGTCTTGCCGGCATCATTGACCTCCCA
AAGGAGGGCACATCAGCTCCGGAAGTGGATATTTACATGGGTCCGAAGAACCAGGGGCTCCTACCAAATGAATGG
GATACTGAATGAAGCACATAATGGGAGGCATGCTTCGCTGTCTAAGGTTGTGCAATTTTGTATGGCATTGGGCGGCA
AAACACCAATTATAGTGTATTAGTTGCGAACAAATGGAATGGCAGCAGCTAAGTTCATGCGGAGTGTCCGAACATGG
GCTAATGAAACATTTGGGTGAGAGAAGGCAATTCAGTTGATAGCTATGGCTACTCCAGAAGACATGAGGATAAATGC
AGAGCACATTAGAATTGCTGATCAATTTGTTGAAGTACCCGGTGGAAACAAACAATAACAATATGCAAATGTCCAAC
TCATAGTGGAGATAGCAGTGAGAACCAGGTTTCTGCTGTTTGGCCTGGTTGGGGCCATGCATCTGAGAATCCTGAA
CTTCCAGATGCACTAAATGCAAACGGAATTGTTTTTCTGGGCCACCATCATCATCAATGAACGCCTAGGTGACAA
GGTTGGTTTCAGCTCTCATTGCTCAAGCAGCAGGGTTCCGACTCTTCTTGGAGTGGATCACAGGTGGAAATTCCAT
TAGAAGTTTGTGGACTCGATACCTGCGGATATGTATAGGAAAGCTTGTGTTAGTACTACGGAGGAAGCACTTGGC
AGTTGTGATGATTGGGTATCCAGCCATGATTAAGCATCATGGGGTGGTGGTGGTAAAGGGATCCGAAAGGTTAA
TAACGACGATGATGTCAGAGCACTGTTAAGCAAGTGAAGGTTGAAGTTCCTGGCTCCCAATATTTATCATGAGAC
TTGCATCTCAGAGTCGACATCTTGAAGTTCAGTTGCTTTGTGATCAATATGGCAATGTAGCTGCGCTTTCACAGTCGT
GACTGCAGTGTGCAACGGCGACACCAAAGATTATTGAGGAAGGACCAGTTACTGTTGCTCCTCGCGAGACAGTGAA
AGAGCTAGAGCAAGCAGCAAGGAGGCTTGCTAAGGCTGTGGGTTATGTTGGTGTGCTACTGTTGAATATCTCTACA
GCATGGAGACTGGTGAATACTATTTTTCTGGAACCTTAATCCACGGTTGCAGGTTGAGCATCCAGTCCACCGAGTGGATA
GCTGAAGTAACTTGCCTGCAGCTCAAGTTGCAGTTGGAATGGGTATACCCCTTTGGCAGGTTCCAGAGATCAGACG
TTTCTATGGAATGGACAATGGAGGAGGCTATGACATTTGGAGGAAAACAGCAGCTCTTGCTACCCCATTTAACTTTG
ATGAAGTGGATTCTCAATGGCCAAAGGGTCAATGTGTAGCAGTTAGGATAACCAGTGGAGATCCAGATGACGGATTC
AAGCCTACCGGTGGAAAAGTAAAGGAGATCAGTTTTAAAAGCAAGCCAAATGTTTGGGCCTATTTCTCTGTAAAGTC
CGTGGAGCATTATGAATTTGCTGATTCTCAGTTTGGACATGTTTTGTCATATGGAGTGTCTAGAGCAGCAGCAA
TAACCAACATGTCTCTTGCCTAAAAGAGATTCAAATTCGTGGAGAAATTCATTCAAATGTTGATTACACAGTTGAT
CTCTTGAATGCCTCAGACTTCAAAGAAAACAGGATTATACTGGCTGGCTGGATAACAGAATAGCAATGCGAGTCCA
AGCTGAGAGACCTCCGTGGTATATTTTTCAGTGGTTGGAGGAGCTCTATATAAAAACAATAACGAGCAACACAGACACTG
TTTTCTGAATATGTTAGCTATCTCGTCAAGGGTTCAGATTCCACCGAAGCATATATCCCTTGTCCATTCAACTGTTTCT
TTGAATATAGAGGAAAGCAAATATAACAATTTGAACTATAAGGAGCGGACAGGGTAGCTACAGATTGCGAATGAATGG
ATCAGTTATTGAAGCAAATGTCCAAACATTATGTGATGGTGGACTTTTTAATGCAGTTGGATGGAAACAGCCATGTAA
TTTTATGCTGAAGAAGAGGCGGTTGGTACACGGCTTCTAATTGATGGAAAGACATGCTTGTACAGAATGATCACGAT
CCTTCAAGGTTATTAGCTGAGACACCCTGCAAACCTTCTTCTGTTTCTTGGTTGCCGATGGTGTCTGTTGAAGCTGA
TGTACCATATGCGGAAGTTGAGGTTATGAAGATGTGCATGCCCTCTTGTACCTGCTGCTGGTGTCTATTAATGTTT
TGTGCTGCTGAGGGCCAGCCTATGCAGGCTGGTGTCTTATAGCAAGACTTGTATCTTGTGACCTTCTGCTGTGAAG
AGAGCTGAGCCGTTTAAACGGATCTTTCCAGAAATGAGCCTTCTTATTGCTGCTTCTGGCCAAGTTCACAAAAGATG
TGCCACAAGCTTGAATGCTGCTCGGATGGTCTTTCAGGATATGATCACCCGATCAACAAAGTTGTACAAGATCTGG
TATCCTGTCTAGATGCTCCTGAGCTTCTTTTCTTACAATGGGAAGAGCTTATGTCTGTTTTAGCAACTAGACTTTCCA
AGGCTTCTTAAAGAGCGAGTTGGAGGGTAAATACAGTGAATATAAGTTAAATGTTGGCCATGGAAAGAGCAAGGATTT
CCCTTCCAAGATGCTAAGAGAGATAATCGAGGAAAATCTTGACATGGTCTGAGAAGGAAATGCTACAAATGAGA
GGCTTGTGAGCCTCTTATGAGCCTACTGAAGTCAATGAGGGTGGCAGAGAAAGCCATGCACACTTTATTTGTGAAG
TCCCTTTTCGAGGACTATCTCTCGGTTGAGGAACTATTCAAGTGTGATGGCATTCAAGTCTGATGTGATTGAACGCCTGCG
CCAACAACATAGTAAAGATCTCCAGAAGGTTGTAGACATTTGTGTTGTCTCACCAGGGTGTGAGAAACAAAACAAAGC
TGATACTAACACTCATGGAGAAACTGGTCTATCCAAACCTGCTGCCACAAGGATCAGTTGACTCGCTTTTCTCTCC
CTCAATCAAAAAGATATATAAGTTGGCCCTTAAAGCTAGCGAGCTTCTTGAACAAACCAAGCTTGTGAGCTCCG
CACAAGCATTGCAAGGAGCCTTTTCAAGCTTGAAGATGCTTACTGAAGAAAGGACGGCCATTAGTGAAGATCATGGGAG
ATTTAGTGACTGCCCCACTGCCAGTTGAAGATGCACTGGTTTTCTTTGTTTGTATTGTAGTGATCAAACCTTTCAGCAG
AGGGTGTATCGAGACGTACATATCTCGATTATACCAGCCTCATCTTGTCAAGGATAGTATCCAGCTGAAATATCAGGA
ATCTGGTGTATTGCTTTATGGGAATTCGCTGAAGCGCATTCAGAGAAGAGATTGGGTGCTATGGTTATTGTGAAGT
CGTTAGAATCTGTATCAGCAGCAATTTGGAGCTGCCTAAAGGGTACATCACGCTATGCAAGCTCTGAGGGTAAACATA
ATGCATATTGCTTTATTTGGGTGCTGATAATCAAATGCATGGAACCTGAAGACAGTGGTGATAACGATCAAGCTCAAGT
CAGGATAGACAAACTTTCTGCGACACTGGAACAAAATACTGTACAGCTGATCTCCGTGCTGCTGGTGTGAAGGTTA
TTAGTTGCATTGTTCAAAGGGATGGAGCACTCATGCCATGCGCCATACCTTCTTCTTGTGCGATGAAAAGCTTTGT
TATGAGGAAGAGCCGTTCTCCGGCATGTGGAGCCTCCTCTTTCTGCTCTTCTTGTGAGTTGGGTAAAGTTGAAAGTGAA
AGGATACAATGAGGTGAAGTATACACCGTCAAGTGTGCTGAGTGGAAACATATAACACACTTAGAAATACAGAGAACC

CCAAAATGTTGCACAGGGTGT'TTTCCGAACTCTTGTGTCAGGCAACCCGGTGCTTCCAACAAATTCACATCAGGCAAC
ATCAGTGATGTTGAAGTGGGAGGAGCTGAGGAATCTCTTTTTCATTTACATCGAGCAGCATATTAAGATCGCTGATGAC
TGCTATAGAAGAGTTGGAGCTTTCACGCGATTAGGACAGGTCACTCTCATATGTTTTTGTGCATATTGAAAGAGCAAA
AGCTTCTTGATCTTGT'TCCCGTTTTCAGGGAAACAAAGTTGTGGATATTGGCCAAGATGAAGCTACTGCATGCTTGCTT
CTGAAAGAAAATGGCTCTACAGATACATGAACTTGTGGGTGCAAGGATGCATCATCTTTCTGTATGCCAATGGGAGGT
GAACTTAAGTTGGACAGCGATGGGCCTGCCAGTGGTACCTGGAGAGTTGTAACAACCAATGTTACTAGTCACACCT
GCACTGTGGATATCTACCGTGAGGTGAAGATAACAGAAATCACAGAACTAGTGTACCACTCTGCTCCATCGTCATCT
GGTCTTTTGCATGGCGTTGCACTGAATACTCCATATCAGCCTTTGAGTGTTATTGATCTGAAACGTTGCTCCGCTAG
AAATAACAGAACTACATACTGCTATGATTTTCCGTTGGCATTGAAACTGCAGTGCAGAAGTCATGGTCTAACATTT
CTAGTGACACTAACCGATGTTATGTTAAAGCGACGGAGCTGGTGT'TTGCTCACAAGAACGGGTCTGGGGCACTCCT
GTAATTCTATGGAGCGTCTGCTGGGCTCAATGACATTGGTATGGTAGCTTGGATCTTGGACATGTCCACTCCTGA
ATATCCCAATGGCAGGCAGATTGTTGTTCATCGCAAATGATATTACTTTTAGAGCTGGATCGTTTTGGTCCAAGGGAAG
ATGCATTTTTTGAAGTGTACCAACCTAGCTTGTGAGAGGAAGCTTCCCTCTCATCTACTTGGCAGCAAACCTCTGGT
GCTCGGATCGGCATAGCAGATGAAGTAAAATCTTGCTTCCGTTGGATGGTCTGATGATGGCAGCCCTGAACGTGG
GTTTTCAATATATTTATCTGACTGAAGAAGACCATGCTCGTATTAGCGCTTCTGTTATAGCGCACAAAGATGCAGCTTG
ATAATGGTGAATTAGGTGGGTTATTGATTCTGTTGTAGGGAAGGAGGATGGGCTAGGTGTGGAGAACATACATGGA
AGTGCTGCTATTGCCAGTGCCTATTCTAGGGCCTATGAGGAGACATTTACGCTTACATTTGTGACTGGAAGGACTGT
TGGAATAGGAGCATATCTTGCTCGACTTGGCATAAGGTCATTGAGGCTACTGACCAGCCATTATCCTAACTGGGT
TCTCTGCCTTGAACAAGCTTCTTGGCCGGGAAGTGTACAGCTCCACATGCAGTTGGGTGGCCCCAAAATTATGGCC
ACAAACGGTGTGTCCATCTGACAGTTTTCAGATGACCTTGAAGGTGTATCTAATATATTGAGGTGGCTCAGCTATGT
TCCTGCCAACATTTGGTGGACCTCTTCCCTATTACAAAATCTTTGGACCCACCTGACAGACCCGTTGCTTACATCCCTG
AGAATACATGTGATCCTCGTGCAGCCATCAGTGGCATTGATGATAGCCAAGGGAAATGGTTGGGGGGTATGTTCCGAC
AAAGACAGTTTTTGTGGAGACATTTGAAGGATGGGCGAAGTCAGTAGTTACTGGCAGAGCGAAACTCGGAGGGATTCC
GGTGGGTGTTATAGCTGTGGAGACACAGACTATGATGCAGCTCATCCCTGCTGATCCAGGTGAGCTTGATTCCCATG
AGCGGTCTGTTCCCTCGTGTGGGCAAGTCTGGTTTCCAGATTCAGCTACTAAGACAGCGCAGGCAATGCTGGACTTC
AACCCTGAAGGATTACCTCTGTTTCTCCTTGAAGTGGAGAGGCTTCTCTGGTGGGCAAAGAGATCTTTTTGAAGG
AATCCTTCAGGCTGGGTCAACAATTGTTGAGAACCTTAGGACATAACAATCAGCCTGCCTTTGTATATATCCCCAAGG
CTGCAGAGCTACGTGGAGGGGCTTGGGTGCTGATTGATAGCAAGATAAATCCAGATCGCATTGAGTTCTATGCTGAG
AGGACTGCAAAGGGCAATGTTCTTGAACCTCAAGGGTTGATTGAGATCAAGTTGAGGTGAGAGGAACTCCAAGAGTG
CATGGGCAGGCTTGACCCAGAATTGATAAAATTTGAAGGCAAACTCCTGGGAGCAAAGCATGAAAATGGAAGTCTAT
CTGAGTCAGAATCCCTTTCAGAAGAGCATAGAAGCCCGGAAGAAAACAGTTGTTGCCTTTGTATACTCAAATTCGGTA
CGGTTTCGCTGAATTGCATGACACTTCCCTTAGAATGGCTGCTAAGGGTGTGATTAAGAAGGTTGTAGACTGGGAAGA
TTCTAGGTCTTTCTTCTACAAGAGATTACGGAGGAGGATATCCGAGGATGTTCTTGCAAAGGAAATTAGAGGTGTAA
GTGGCAAGCAGTTTTCTCACCAATCGGCAATCGAGCTGATCCAGAAATGGTACTTGGCCTTAAGGGAGCTGAAACG
GAAACACTGAATGGGATGATGACGATGCTTTTTGTTGCCTGGAGGGAAAACCTGAAAACCTACCAGGAGTATATCAA
AGAACTCAGGGCTCAAAGGGTATCTCAGTTGCTCTCAGATGTTGCAGACTCCAGTCCAGATCTAGAAGCCTTGCCAC
AGGGTCTTTCTATGCTACTAGAGAAGATGGATCCCTCAAGGAGAGCACAGTTTTGTTGAGGAAGTCAAGAAGGCCCTT
AAATGA

FIGURE 16B

>ACD46679_Aegilops tauschii (jointed goatgrass)
 MGSTHLPIVGLNASTTPSLSTIRPVNSAGAAFQPSAPSRTSKKKSRRVQSLRDGGDGGVSDPNQSIROGL
 AGIIDLPKEGTSAPEVDISHGSEEPGRSYQMNGILNEAHNGRHASLSKVVEFCMALGGKTPIHSLVANN
 GMAAAKFMRSVRTWANETFGESEKAIQLIAMATPEDMRINAEHIRIADQFVEVPGGTNNNNYANVQLIVEI
 AVRTGVS AVWPGWGHASENPEL PDALNANGI VFLGPPSSSMNALGDKVGSALIAQAAGVPTLPWSGSQVE
 I PLEVCLDSIPADMYRKACVSTTEEALASCQMIGYPAMIKASWGGGGKGIKRVNDDDDVRALFKQVQGEV
 PGSPIFIMRLASQSRHLEVQLLCDQYGNVAALHSRDCSVQRRHQKIEEGPVTVPAPRETVKELEQAARRL
 AKAVGYVGAATVEYLYSMETGEYYFLELNPRLQVEHPVTEWIAEVNLPAAQVAVGMGIPLWQVPEIRRFY
 GMDNNGGYDIWRKTAALATPFNFDEVDSQWPKGHCVAVRITSEDPDDGFKPTGGKVKKEISFKSKPNVWAY
 FSVKSGGGIHEFADSQFGHVFAYGVSRAAAITNMSLALKEIQIRGEIHSNVDTVDLLNASDFKENRIHT
 GWLDNRIAMRVQAERPPWYISVVGGALYKTTISNTDTVSEYVSYLKVGQIPPKHISLVHSTVSLNIEESK
 YTIETIRSGQGSYRLRMNGSVIEANVQTLCDGGLLMQLDGNHSHVYAEAAAAGGTRLLIDGKTCLLQNDHD
 PSRLLAETPCKLLRFLVADGAHVEADVPEAEVEVMKMCMLLSPAAGVINVLLSEGQPMQAGDLIARLDL
 DDPSAVKRAEPFNGSFPMSLPIAASGQVHKRCATSLNAARMVLAGYDHPINKVVQDLVSLDAPLPLFL
 QWHEELMSVLATRLPRLKSELEGKYSEYKLVNMGHGKSKDFPSKMLREIIEENLAHGSEKEIATNERLVEP
 LMSLLKSYEGGRESHAFIVKSLFEDYLSVEELFSDGIQSDVIERLRQQHSDLQKVVDIVLSHQGVRNK
 TKLILTLMEKLVYPNPAAYKQDLTRFSSLNHKRYKALKASELLEQTKLSELRTSIARSLSELEMFTEE
 RTAISEIMGDLVTAPLPVEDALVSLFDCSDQTLQQRVIETYISRLYQPHLVKDSIQLKYQESGVIALWEF
 AEAHSEKRLGAMVIVKSLESVSAAGIAGALKGTSTRYASSEGNIMHIALLGADNQMHGTEDSGDNDQAQVRI
 DKLSATLEQNTVTADLRAAGVKVISCIVQRD GALMPMRHTFLLSDEKLCYEEEPVLRHVEPPLSALLELG
 KLKVKGYNEVKYTPSRDRQWNIYTLRNTENPKMLHRVFFRTLVRQPGASNKFTSGNISDVEVGGAEESLS
 FTSSSILRSLMTAIEEELHAI RTGHSHMFLCILKEQKLLDLVPVSGNKVVDIGQDEATACLLLKEMALQ
 IHELVGARMHHSVCQWEVKLKLDSGDPASGTWRVVTNTVTSHTCTVDIYREVEDTESQKLVYHSAPSSS
 GPLHGVALNTPYQPLSVIDLKRCSARNRRTTYCYDFPLAFETAVQKSWSNISSDTNRCYVKATELVFAHK
 NGSWGTPIVPMERPAGLNDIGMVAWILDMSTPEYPNGRQIVVIANDITFRAGSFGPREDAFFETVTNLAC
 ERKLP LIYLAANS GARIGI ADEVKSCFRVGSDDGSPERGFQYIYLTEEDHARISASVIAHKMQLDNGEI
 RWVIDSVVGKEDGLGVENIHGSAAIASAYSRAYEETFLLTFVVTGRTVIGAYLARLGIRCIQRTDQPIIL
 TGFSALNKLLGREVYSSHMQLGGPKIMATNGVVHLTVSDDLEGVSNILRWLSYVPANIGGPLPITKSLDP
 PDRPVAYIPENTCDPRAAISGIDDSQGWLGGMFDKDSFVETFEGWAKSVVTGRAKLGIPVGVIAVETQ
 TMMQLIPADPGQLDSHERSVPRAGQVWFPDSATKTAQAMLDNFNREGLPLFILANWRGFSGGQDLFEGIL
 QAGSTIVENLRTYNQPAFVYIPKAAELRGGAWVIDSKINPDRIEFYAERTAKGNVLEPQGLIEIKFRSE
 ELQECMGRLDPELINLKAKLLGAKHENGSLSESESLQKSI EARKKQLLPLYTQI AVRFAELHDTSLRMAA
 KGVIKKVVWDWEDSRFFYKRLRRRISEDVLAKIIRGVSGKQFSHQSAIELIQKWYLASKGAETGNTEWDD
 DDAFVAWRENPENYQEYIKELRAQRVSQLLSDVADSSPDLEALPQGLSMLLEKMDPSRRAQFVEEVKKAL
 K