Amaranthus Enhancement Breeding at the North Central Regional Plant Introduction Station

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Introduction

Amaranthus Enhancement Breeding at the North Central Regional Plant Introduction Station.
The genus *Amaranthus* is grown commercially for high-value edible seeds, vegetable, forage and ornamental uses. Enhancement breeding is to develop traits that are not available in commercial varieties. This breeding is compatible with the conservation, maintenance, characterization, and evaluation activities that support a collection of 3300 accessions of diverse *Amaranthus* germplasm accessions for use in research and crop improvement. Iowa State University has released five improved lines; their traits include non-shattering seed cases and large stems with good resistance to lodging for biomass. The non-shattering trait results in better seed retention for potentially improved grain yields, and improved ornamental lines for cut-flower use. Phenotypic trait evaluation information can be found in the GRIN database (www.ars-grin.gov). Accessions have been identified with the following traits: non-shattering, male sterility, heavy seeds, and dark red foliage. Accessions with red foliage pigmentation have potential for use in food coloring. I am collaborating with others on measuring outcrossing with weedy *Amaranthus* species. Minimal outcrossing with weedy species may be useful for maintaining pure commercial lines.

Introduction to amaranth as a crop
In the United States, amaranth grain is cultivated mostly in western Nebraska, as a specialty crop. The grain is marketed as a nutritious high value food for people. It is a good alternative food for people that have allergies to the gluten in other grains. Amaranth grain is popular in India, Kenya, Mexico, Peru, and other countries. The foliage is used as a vegetable, especially in tropical and sub-tropical areas, and is popular in Asia, and in the Caribbean. Many local varieties are used in regional cooking traditions. Ornamental amaranths are in widespread use. Amaranth bedding plants and seeds are offered by most garden centers in the United States.

Improved Amaranths Released By Iowa State University
www.ag.iastate.edu/centers/cad/amaranth.html

Non Shattering
The populations DB 92226 and DB 9350 have little or no abscission at the equator of the utricle, or beneath the utricle. They are intended to reduce grain shattering via crossing with standard cultivars. The non-shattering trait found in both lines is derived from PI 572261 (*Amaranthus powellii*).

DB 9350 (*Amaranthus cruentus*) plants are single stemmed, non-branching. The inflorescence is pink with distinctive, very short pedicels, making the inflorescence arms unusually compact. The seeds are black or white.

DB 92226 (*Amaranthus hypochondriacus*) plants are single stemmed or multi stemmed. The inflorescence is red or green and the seeds are white.

These utricles are the shattering type with abscission at the equator

DB 98246 *A. cruentus* for biomass research

'Pillar Red' ornamental *A. hypochondriacus*

Biomass DB 98246 (*Amaranthus cruentus*)
Combines large growth with strong stems that resist lodging. It is intended for forage or biomass production. It yielded nine metric tons (dry basis) per hectare, with a dry matter content of 28% as determined by Pavel Muchna, of LOBODON, s.r.o., in the Czech Republic. The seeds are white and non-dormant, which is important for stand establishment and reduced volunteering in subsequent years. The plants are dark red. The non-shattering trait derives from the DB 9350 parent, and is from a cross between DB 9350 and PI 566897.

Ornamental "Pillar Orange" and "Pillar Red" (*Amaranthus hypochondriacus*)
These varieties may be used as tall specimen plants (170 cm) as well as cut flowers. As a cut-flower ornamental amaranth they are non-shattering, do not shed seeds, and are therefore cleaner than existing ornamental amaranths. The inflorescence is denser than any other existing commercial amaranth variety. The increased density improves inflorescence sturdiness, increasing cut flower shelf life, and discouraging insects from populating the inflorescence. The seeds are white and non-dormant, so it seldom volunteers as a weed in the following growth season. The plants are 170 cm tall with an inflorescence 75 cm long in the Ames, Iowa field nursery location. If the central inflorescence is removed, smaller, 45 cm long secondary inflorescences emerge as side shoots that are of a length well suited to routine use by florists. These observations are based on spacing of four inches in rows three feet wide. It seems reasonable that closer spacing would increase competition, and dwarf the plants. The flowers mature and harvestable from late August to mid October from direct field seeding during the first week of June. Due to the sturdiness of the inflorescence and plants, the harvest season extends about four to six weeks. Experience with winter short-day length greenhouse environments suggests that plants would mature about three months after planting and grow approximately 30 cm tall. These two Iowa State University ornamental variety releases are derived from amaranth varieties provided by David D. Baltensperger and others (the grain variety 'Plainsman' PI 558499); and Peter Kulakow ('Elephant Head' PI 584523).

PI 558499 among weedy *Amaranthus* plants for a field outcrossing study

Off-type hybrids are distinct from true-to-type plants in this progeny test

Trait Exploration and Evaluation

***Amaranthus* traits posted on the GRIN database.** www.ars-grin.gov/npgs/
The 40,500 *Amaranthus* observations posted on GRIN help guide the selection of accessions for research. The observations include:

3,325 accessions with seed weight data from .010 to .290 grams per 100 seeds
150 accessions with observed male sterility
108 accessions with non-shattering traits
26 reference accessions with unusual traits such as dark red foliage that may be used as food coloring

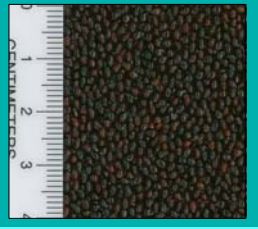
Ongoing Projects

Dwarf amaranths
I have a long-term goal of identifying and developing dwarf grain amaranth germplasm and collaborating on dwarf amaranth research. Better dwarf germplasm could reduce crop losses from lodging.
PI 568179 *Amaranthus* hybrid Blooms 20 days after flowering regardless of daylength.
DB 2005652 *Amaranthus caudatus* grows as a rosette about 4 cm tall, segregated from PI 481007
DB 2003833 *Amaranthus cruentus* is 150 cm tall and was selected in a spaced nursery in 2003
DB 2003853 *Amaranthus hypochondriacus* is 140 cm tall and was selected in a spaced nursery in 2003

DB 2005652 A spontaneous mutant dwarf *A. caudatus* that grows about 4 cm tall

Precluding crop-weed hybridization
In the 2007 field season, ten cooperators in the US participated in a study of out-crossing in grain amaranths. Two accessions (PI 558499 and PI 538327) were planted by cooperators in locations where local weeds could cross with them. The out-crossing frequencies for these two PIs will be compared, based on the frequency of crop-weed hybrids in the harvested progenies. This project supports the objective of reducing the frequency of undesirable off-type, dark weed-hybrid seeds, in grain harvests. PI 538327 is of special interest because it did not outcross with weeds in our 2005 field trial.

DB 2003853 dwarf breeding line



On the left, white crop seeds of PI 558499, 'Plainsman' hundred seed weight 0.07 g
On the right, black seeds of PI 553084, wild *A. pumilus* hundred seed weight 0.29 g

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