LEGACY

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The 1995 Annual Meeting

The next Amaranth Institute annual meeting will be October 22-25, in conjunction with the Third National Symposium on New Crops, in Indianapolis, Indiana.

IRON AVAILABILITY FROM *Amaranthus* SPECIES

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Iron deficiency is one of the most prevalent mineral nutrient deficiencies affecting humans in the world, especially among women of child bearing age and young children (Fritz et al 1970). Actual numbers of persons affected by iron deficiency are difficult to determine, but one estimate is between .75 and 1 billion people around the world (Chidambaram et al 1989). The incidence of iron deficiency is particularly high in developing regions of the world, where widespread poverty may limit food access or quality. Because supplemental iron sources are often better utilized than many food iron sources, these are popular interventions to combat iron deficiency (Fritz et al 1970). However, the effectiveness of iron supplementation programs may be limited by the socioeconomic conditions and isolation of the populations in developing countries (Monsen 1988). In these cases, improvements in the bioavailability of iron from the foods regularly consumed may be more efficient and effective than provision of supplements (Monsen 1988).

Green leafy vegetables (GLVs) are one food source which would be suitable for improvement of iron bioavailability. GLVs have a high concentration of iron per unit calorie as well as wide use and acceptability, providing flavor, texture and variety to meals. These vegetables often have very high productivity, being grown intensively and cheaply on small farms or in home gardens or collected from the wild in many developing regions. *Amaranthus* species are native GLVs with low cost, high productivity, and stress tolerance and are cultivated and consumed in many developing regions of the world. Improvement in the iron nutritional quality of this vegetable could provide a significant food source for many resource poor individuals around the world, especially women and children. A few studies have examined the iron nutritional quality of vegetable amaranth. However, these studies often utilized a "market basket" approach, in which foods were collected from local markets and analyzed for iron content. Although this method does provide information on the amount of iron people may consume, it provides no indication of the differences in iron bioavailability due to genetic variation or cultural practices. One study found that amaranth lines with the highest total iron concentration do not have the highest available iron (Reddy and Kulkarni 1976), suggesting that genetic variability for iron availability exists. This research further explores the genetic variability in iron bioavailability from amaranth species to determine if opportunity exists for breeding to enhance the nutritional quality of this high iron-accumulating GLV.

Several lines from the following 12 species of amaranth were selected from the Plant Introduction Station collection at Ames, Iowa: *A. tricolor, A. dubius, A. hybridus, A. caudatus, A. viridis, A. cruentus, A. spinosus, A. lividus, A. hypochondriacus, A. rudis, A. palmerii* and *A.* species. The lines included both cultivated and wild types and grain and vegetable types from diverse regions of the world. Lines were direct seeded, in the field, in a randomized block design, with 4 blocks. Irrigation was applied as needed to supplement rainfall to a minimum of 1" of water per week. No pesticides were applied, and all weeding was done by hand. Plants were harvested 35 days after seeding, washed to remove surface soil contamination, freeze dried and ground. Total iron was determined using atomic absorption spectrophotometry. The assay for in vitro available iron identified low molecular weight iron as bioavailable if it remained in solution after a simulation of gastrointestinal digestion (Kapsokefalou and Miller 1991).

Total iron content of the leaves ranged from 388 to 814 ppm. The lines from *A. lividus*, *A. spinosus*, and *A. tricolor* accumulated the highest concentration of total iron, averaging between 700 and 800 ppm. The species with the lowest iron concentration, *A. hypochondriacus*, accumulated 388 ppm, approximately half the concentration of the highest, *A. lividus*. In vitro digestion provided estimates of available iron ranging from 43 to 57 ppm, with *A. lividus, A. spinosus, A. dubius*, and *A. tricolor* having the highest available iron. Although total iron concentrations did not correlate well with available iron, species with higher total iron tended to have higher available iron. The percent of total iron available may be useful for identification of lines which contain forms of iron relatively more available or which accumulate compounds which enhance iron availability relative to other lines. The size of the fraction of available iron varied by species, ranging from 7 to 12 percent of total iron.

The differences observed in total and available iron among the species of amaranth indicated genetic variability that may be utilized to increase the iron nutritional quality. Especially promising were the lines of *A. tricolor*. This species, along with *A. lividus*, and *A. spinosus*, which accumulated high levels of total iron, are used predominately as vegetable types, whereas *A. hypochondriacus*, which accumulated the lowest levels of iron, is predominately a grain type. The differences in leaf area and plant morphology may be related to the differences in iron content but were not explored in this study. Future work will focus on vegetable types for improving iron nutritional quality.

The in vitro method of estimating iron bioavailability is useful to make relative comparisons among test material, but does not indicate absolute availability. Determination of actual bioavailability would require animal or human feeding studies and an examination of meal interactions. If the values observed in this study were actual bioavailabilities, comparisons of iron contribution between the two extreme lines may provide some indication of potential improvement in the iron status of the diet by changing amaranth types. If dry weight is estimated to be approximately 10% of fresh weight, then the expected iron absorbed from the lines with the lowest and highest bioavailable iron would be .43 and .57 mg/100 g fresh material. The iron requirement for men is 1 mg/day and women is 2 mg/day. Daily 100g portions of amaranth could provide 43 to 57% of the daily requirement for men and children and 21 to 28% for women. Amaranth provides significant amounts of iron (and other nutrients) to the diet, and, as a low cost vegetable, would be an economical source as well. Future work will compare *A. tricolor* and *A. hypochondriacus* using an animal model, to verify the differences.

REFERENCES CITED:

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Amaranth Logo
A logo is in development for any marketers to use on amaranth product packages. People interested in participation on this project should contact the Amaranth Institute President.

Amaranth Bread in Supermarkets
Two breads that contain amaranth flour are available now in supermarkets: Brownberry Natural 12 Grain Bread, and Pepperidge Farm Natural 9 Grain Bread.

REGIONAL AMARANTH VARIETY TEST

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A test of improved amaranth germplasm has been conducted on a regional basis in the U.S. and Canada during the last several years. Most of the "varieties" shown in the tables below were released as improved lines, or selections, by the Rodale Research Center (Kurtztown, PA). Plainsman is a release of the University of Nebraska Experiment Station, while Amont is a release of the Montana State University Experiment (note: Plainsman represents a selection from Rodale line K343). A200D is a variety sold by Nu-World Amaranth, Inc. (Naperville, IL).

Plainsman is currently the variety most commonly grown in commercial production. In general, there are significant differences in height, leaf and inflorescence color, maturity, and plant architecture among the varieties reported on here. Data indicates that D136 has shown significant lodging resistance compared to other varieties in the test.

The regional test has involved typically 8 to 14 sites per year, primarily in the Midwest and Great Plains, with a few tests in Canada. Data reported here is limited to states that have conducted several years of amaranth testing. Leon Weber of the Rodale Center was the first coordinator of the test, followed by Dan Putnam of the University of Minnesota in 1990 and 1991 (Dr. Putnam is now at the University of California-Davis). Rob Myers at the University of Missouri has been providing coordination of the test since 1992.

Data reported in the table below is in pounds per acre (1 lb/acre = 1.1 kg/ha). Yields have been normalized to a standard moisture by each cooperating researcher (standard moistures used varied from 10% to 12%). Each state has had poor years or sites where most or all varieties yielded only a few hundred pounds per acre. On the other hand, each state has had at least one or two occasions where good yields of over 1000 pounds per acre were reported for most varieties. Most low yields could be explained by poor harvest conditions leading to pre-harvest loss from shatter, lodging, or other problems. Spotty stand establishment has occasionally been a major yield limitation.

For some sites, additional lines were tested besides those shown, and if so, LSD values shown here were based on error of those additional lines as well as lines shown.

Variety/line	Species	Maturity	Height	Flower Color	Parents (male x female)
Plainsman	*A. hypochondriacus*	mid	medium	maroon	1023 x 1004
Amont	*A. cruentus*	late	tall	green	na
D70-1	*A. hypochondriacus*	mid	tall	maroon	(1023 x SP153) x (1024 x 27)
D136-1	*A. hypochondriacus*	late	medium	green	(1023 x 892) x (51 x 386)
K266	*A. cruentus*	late	tall	green	1013 x 60
K283	*A. cruentus*	mid	tall	maroon	1012 x 1035
K432	*A. hypochondriacus*	early	short	green-gold	51 x 386
K433	*A. hypochondriacus*	early	short	green	51 x 386
K436	*A. cruentus*	mid	tall	maroon	1012 x 1035
K593	*A. hypochondriacus*	mid	medium	maroon	1023 x (1023 x SP153)
A200D	*A. cruentus*	mid	medium	maroon	na

Colorado *Principal Investigator: Duane Johnson*

Variety/Line	Ft. Collins	Mead	Ft. Collins	Rocky Ford	Rocky Ford
	1985	*1986*	*1987*	*1988*	*1991*
Plainsman		1386	700	1891	2306
K266		1281	883		1502
K283		1578	1066		2143
K432					1527
K433					1207
1011	1475		816		
K264	1535				
LSD (0.05)	205	NA	283	NA	NA

No data on Amont, A200D, D70-1, or D136-1.

Missouri *Principal Investigator: Rob Myers*

Variety/Line	Columbia			New Franklin	
	1990	*1991*	*1992*	*1990*	*1991*
Plainsman	250	1732	362	199	1207
Amont	378	1717	-	292	964
D70-1	261	1370	-	295	1248
D136-1	325	1229	1195	394	1153
K266	327	1472	444	375	1197
K283	282	1304	281	236	1021
K432	215	1398	431	161	1224
K433	253	1566	425	190	1529
K436	210	1343	443	208	1050
K593	161	1387	344	277	1131
A200D	346	1742	502	276	1076
LSD (0.05)	110	351	223	108	294

Minnesota *Principal Investigator: Dan Putnam*

Variety/Line	Albert Lea	Grand Rapids	Grand Rapids	Lamberton	St. Paul
	1989	*1989*	*1990*	*1990*	*1990*
Plainsman	1031	492	1326	629	1634
Amont			1171	1064	1970
D136-1				956	1498
K266	1306			1072	2055
K283	1166			444	1329
K432	1570	1051	1397	735	1550
LSD (0.05)	349	137	198	393	306

No data on D70-1, K433, K436, K593, or A200D.

Minnesota (continued)

Variety/Line	Rosemount				
	1987	*1988*	*1989*	*1990*	*1991*
Plainsman	1707	1076	1731	910	1254
Amont				1018	1650
D136-1				893	685
K266	2024	1091		1299	1338
K283	804	1168		679	
K432		1247	1824	1117	
A200D			1264	729	
LSD (0.05)	268	297	437	193	221

No data on D70-1, K433, K436, or K593.

Nebraska *Principal Investigator: David Baltensperger*

Variety/Line		Sidney			Scottsbluff
	1991	*1991*	*1992*	*1993*	*1993*
Plainsman	816	820	1550	640	800
Amont	513	650	1090	190	-
D70-1	350	620	1480	440	-
D136-1	48	210	980	110	170
K266	435	360	760	220	220
K283	360	500	780	200	320
K432	569	610	1460	670	1010
K433	859	680	1330	650	1260
K436	331	270	630	120	110
K593	710	510	1600	330	760
A200D	520	520	1490	290	-
LSD (0.05)	293	NA	310	160	220

North Dakota *Principal Investigators: Al Schneiter and Blaine Schatz*

Variety/Line	Fargo (87-88)		Prosper (89-92)			
	1987	*1988*	*1989*	*1990*	*1991*	*1992*
Plainsman	1500	233	845	1773	930	981
Amont				2350	1113	
D70-1				1732	1127	159
D136-1				426	181	18
K266	1487		966	1957	1109	989
K283	1590	684	1159	1645	1144	1606
K432		350	741	1514	1041	1570
K433			742	1600	710	1076
K436			950	1739	887	547
K593				1581	1002	583
A200D			735	1757	964	72
LSD (0.05)	699	273	381	387	378	356

International Conference on Amaranth
The conference will be August 29 through September 1, 1994 in the Czech Republic. Write to: Bohemia Amaranth, Wolkerova 31, 779 00 Olomouc, Czech Republic phone:0042-068-5413562, fax:0042-068-5413119.

Alternative Agricultural Research and Commercialization Center
The AARC administers grants from the United States Department of Agriculture, for precommercial tasks, targeted research, and development of new products. Information is available from: Patricia Dunn, USDA AARC Center, Ag Box 0400, 14th & Independence Ave. SW., Cotton Annex, 2nd flr Mez, Washington, DC 20250-0400 phone 202-401-4860 fax 202-401-6068.

New Bioherbicide To Control Weed Amaranths. Scientists at the Plant Pathology Department, University of Florida, Gainesville, have isolated a new fungal disease *Phomopis amaranthicola* which is pathogenic on at least 22 species of Amaranthus. This new *Phomopis* has potential for use as a bioherbicide. An abstract was published in: Phytopathology Vol.83(12):1385 by E.N. Rosskopf, R. Charudattan, and J.T. DeValerio.

Other Amaranth Newsletters Two other amaranth newsletters are available. **Amaranth Newsletter** is published in separate English and Spanish editions by Dr. Ricardo Bressani, Universidad del Valle de Guatemala, Instituto de Investigaciones, Apartado Postal 82, 01901, Guatemala, Guatemala, C.A. The Subscription cost is US$20 per year, write your check to: "El Amaranto y Su Potential". **Amarantos Novedades e Informaciones** is published in Spanish by the Facuitad de Agronomia, de la Universidad Nacional de la Pampa, y Estacion Experimental Agropecuaria Anguil, La Pampa (INTA), República Argentina.

Amaranth: Ancient Grain Modern Greens. D. Jason. Organic Gardening. 1993 April:40-45
A popular article about varieties of amaranth for grain and vegetable use. Recipes, horticultural advice, and commercial seed sources are provided. The author owns and operates Salt Spring Seeds in Ganges, BC, Canada.

Protein Quality Evaluation of Amaranth in Adult Humans. R. Bressani, E.C.M. De Martell, and C.M. De Godinez. Plant Foods for Human Nutrition. 1993 43:123-143
Popped or extruded amaranth grain both have protein of a similar biological value to the protein of cheese. The first author is at the Institute of Nutrition of Central America and Panama, Guatemala, Guatemala.

Molecular Cloning of a Gene Encoding a Seed-specific Protein With Nutritionally Balanced Amino Acid Composition From *Amaranthus*. Anjana Raina, and Asis Datta. Proceedings of the National Academy of Science USA. December 1992 89:11774-11778
A DNA clone has been isolated that encodes a nutritionally excellent amaranth seed protein. This is a step toward genetically engineering food plants, other than amaranths, to have amaranth protein. The authors are at Jawaharial Nehru University, New

Delhi, India.

Hypocholesterolemic Effect of Amaranth Seeds (*Amaranthus esculantus*). A. Chaturvedi, G. Sarojini, and N.L. Devi. Plant food for Human Nutrition. 1993 44:63-70

White rats benefited from a diet of amaranth grain. The authors are at A. P. Agricultural University, Hyderabad, India.

Chemical and Nutritional Evaluation of Two Amaranth (*Amaranthus cruentus*)-based Infant Formulas. F.R. Del Valle, M. Escobedo, A. Sanchez-Marroquin, H. Bourges, M.A. Bock, and P. Biemer. Plant Foods for Human Nutrition. 1993 43:145-156

An amaranth formula would be an effective and lower-cost alternative to a soy-oat formula. The amaranth product would be more acceptable to Tarahumara Indians that already know amaranth as a local product. The authors are at universities in Mexico and the United States.

AMARANTH: BIOLOGY, CHEMISTRY, AND TECHNOLOGY

A new book on amaranth has been published by CRC press titled, *Amaranth: Biology, Chemistry, and Technology*. A description of the book provided by CRC Press is printed below. For those of us interested in promoting the use of amaranth this publication will provide worthwhile current information. The listed price of the book is $169.95 in the U.S. and $204 outside the U.S. I have arranged for The Amaranth Institute to purchase the books in quantity for $100.00 plus about $10.00 shipping and handling. If you are interested in purchasing this book through the Amaranth Institute, please send a post card or letter to Peter Kulakow, 609 S. Eleventh St., Salina KS 67401 by October 31. Do not send money. When I have received the minimum order of ten books, I will notify you to send a check for the purchase price plus handling. When the money is received we will order the books. If we don't have sufficient interest by October 31, 1994 I will notify you.

Amaranth Biology, Chemistry, and Technology

Edited by Octavio Paredes-López
National Polytechnic Institute, Irapuato, Mexico
Catalog no. 5374MDM May 1994, c. 224 pp., ISBN: 0-8493-5374-2
Approx. U.S. $169.95/ Outside U. S. $204.00CRC Press, Inc., 2000 Corporate Blvd., N.W., Boca Raton, Florida 33431-9868

This book is devoted to amaranth, of which 45 species are indigenous to the Mesoamerican region and 10 others originated in Africa, Asia, and Europe. Amaranth was the foundation of the extensive North and South American ancient civilizations and was still important in the agriculture of more recent Indian cultures. However, this plant nearly disappeared after the Spanish conquest. In view of the outstanding agronomic performance of the plant and the high nutritional value of the grain, it is now becoming an important crop in various regions of the world. Progress in the utilization of amaranth is directly related to scientific and technical information on it's biological, physical, and chemical properties.

"Amaranth" begins with a chapter on the use of tissue culture, molecular biology, and genetic engineering techniques for crop improvement. The next few chapters deal with classical genetics, traditional plant breeding, and plant physiology. Following chapters review the properties of storage and leaf proteins, carbohydrates (especially starch), and seed oil. The potential of amaranth for new food products and popping is discussed, and commercialization and marketing of amaranth and its products are described. The book also emphasizes the outstanding nutritional properties of amaranth.

Features

* Discusses classical genetics, plant breeding, and molecular biology techniques
* Covers various physiological aspects of amaranth
* Describes storage proteins, starch, and oil
* Explores food uses and new food products from amaranth
* Examines the nutritional properties of amaranth

Contents

AMARANTH IN ROTATIONS UPDATE FROM 1993

Tom Frantzen
1155 Jasper Ave.
New Hampton, IA 50659

In 1993, we continued our study of the rotational effect of grain amaranth. Our trial in 1992 (Frantzen, 1993) revealed a 31 bushel/acre corn yield reduction following amaranth compared to corn following soybeans.

Trial circumstances were different than ideal. Corn following corn was compared to corn following amaranth. Corn after corn required additional nitrogen, the late spring test was 13, and yielded 11.2 bushel less than corn after amaranth. Corn after amaranth had a soil N test of 23PPM. This trial should have had corn after soybeans but it was not possible this past year.

Another trial on our farm compared soybeans after amaranth to soybeans after corn. No yield difference was found. The plot was planted June 30th.

Both trials were randomized and replicated 6 times.

Our amaranth yielded 1300# per acre in 1993. We intend to continue on farm research with this alternative crop. For 1994, we will compare planting dates and sidedress fertilizer ideas.

Tom and Irene Frantzen and their three children farm in Northeast Iowa and are members of the Practical Farmers of Iowa.

They host annual tours showing on farm research and promote sustainable agriculture.

REFERENCES CITED:

Frantzen, T. 1993. Amaranth in rotations. Legacy 6: 4-5

AMARANTH INSTITUTE MEMBERSHIP

The member's dues are $10 per year. Write to: Amaranth Institute, c/o James Lehmann, PO Box 248, Bricelyn, MN 56014.

PUBLICATIONS FOR SALE

*1988 *Legacy,* Vol. 1, (includes review of amaranth carbohydrates)
*1989 *Legacy,* Vol. 2, (includes review of amaranth proteins)
*1990 *Legacy,* Vol. 3, (includes review of amaranth pigments and seed shattering)
*1991 *Legacy,* Vol. 4, (includes review of amaranth lipids and release of the variety "Plainsman")
*1992 *Legacy,* Vol. 5, (includes review of anti-nutritional factors in amaranth grain, and tarnished plant bugs)
*1993 *Legacy*, Vol. 6, (includes rotations, tissue culture, hybrid seeds, and planting black seeds)
*Bumper-sticker "Amaranth is coming..."
All the volumes of *Legacy* are available without charge to members.
*1990 *Amaranth Grain Production Guide*, 36 pp. is OUT OF PRINT A revision is planned for 1995.

Legacy is edited by David Brenner, North Central Regional Plant Introduction Station, Iowa State University, Ames, Iowa 50011. Manuscripts and information for publication in *Legacy* are very welcome.

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