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Original paper

Improved varietal technology for enhanced productivity in Grain amaranth

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ABSTRACT

Grain amaranth is a multipurpose crop that can be grown for a variety of uses like food, feed, forage and fuel, and is well adapted to different soil and weather conditions. there is distinct seasonal adaptation of grain amaranth cultivars and commodity-specific cultivars for grain that exemplify the adaptation and diversity in grain amaranth as a crop. The research efforts over four decades have resulted in the release of 25 improved cultivars at the national level and state level with traits of high grain yield, biotic, abiotic resistance and quality traits.

Introduction

Amaranthus, collectively known as amaranth or pigweed, is a cosmopolitan genus of herbs. Amaranths are fast growing, cereal like (pseudo-cereal) plants that produce high protein, minerals and other beneficial aminoacids. Amaranths belong to the family Amaranthaceae and are referred as pseudo-cereal to distinguish them from true cereals which belong to family Gramineae / Poaceae. Amaranth plants are annual, erect, fast growing semi-hard plants with broad leaves and have creamy, pinkish or reddish inflorescence that produce very small round seeds of varying colours and luster and are rich in proteins and minerals. The plants vary from branched to unbranched types. There are about 75 species in genus '*Amaranthus*'. Two sections are recognized in this genus: Amaranthotypus Dumort (Out crossing species) and Blitopsis Dumort (Species with large extent of self –pollination). The grain species belong to section Amaranthotypus. Some of the species in this group are dioecious, but most of the species are monoecious having compound inflorescence. Most of the species have 2n = 32 or 34 except polyploid species

Amaranthus dubius which has 2n = 64. About 20 species are found as wild or/ the useful species of grain amaranth.

Distribution and Adaptation

Amaranths are widely distributed throughout the Old and New World. Sixty species of the genus *Amaranthus* are reported native to the New World and about 15 to the Old World and Australia. In Asia-Pacific region covering India, China, Manchuria, Nepal, Bhutan, Afghanistan, Indonesia, Japan, Thailand and Israel, these are cultivated as minor crops and sporadic in nature. In India, these are cultivated both in hills as well as plains covering states of Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Assam, Meghalaya, Arunachal Pradesh, Nagaland, Tripura, Jharkhand, Chhattisgarh, Maharashtra, Gujarat, Odisha, Karnataka, Kerala and Tamil Nadu.

The exact information about the statistics on area and production in India is lacking. However, it is estimated that the crop is grown in about 40-50 thousands ha in the country. The crop is mainly cultivated in mid and high hills of the Himalayan region as a pure as well as mixed crop. The crop is sporadically grown in other parts of the country including North Eastern region. In Gujarat, the area under this crop is increasing, particularly in Banaskantha district where this crop replaces wheat and potato because of water scarcity. At present, the area in this district alone is estimated to be around 12000 ha and the grain market at Palanpur receives about 6 – 15 thousand tones of grains annually.

Nutritional value

This crop posses an exceptionally high nutritive value with high content of protein, lipids and minerals as well as balance composition of essential amino acids. The tiny seeds of grain amaranth can be compared favorably with maize and other true cereals for its nutritional values and yield. It is an excellent source of iron and b-carotene and thus can help in circumventing iron and vitamin 'A' deficiency. Presence of higher amount of folic acid also helps in increasing the blood haemoglobin level in human beings. The grains are gluten free and act as a good food supplement among the patients suffering from celiac disease. Amaranth is thus an ideal crop having better nutritional properties and endowed with C_4 metabolism suited to survive and thrive in an environment affected by climate change. The protein in amaranth seeds being of high quality, 'AMA-1' gene has been isolated from this crop and is being introduced in to other important food crops like rice and potato. In potato the product with higher yield and protein content has been found to be safe. The product has cleared tests related to toxicity and other side effects. The leaves are also rich in protein and are extremely useful from human nutrition viewpoint.

Uses

- Amaranth has multiple uses. Its tender leaves are used as vegetable.
- The grains are used in various culinary preparations. Popped grains are used in the form of puddings or mixed with sugar syrup to make sweet balls (*laddoo*), with

honey to make flat round breading and with milk and sugar to make porridge. The grains are also used for making candy. The grains can be used in the preparation of breads, biscuits, flakes, cake, pastry, crackers, ice-cream, and lysine rich baby foods. Its flour can be used for making *chappatis* when mixed with maize and finger millet flour. Grains can also be fermented for making beer.

- Amaranth is reported to have several other agro-industrial uses as well. It has great potential for application in high quality plastics, cosmetics, pharmaceuticals and natural dyes. The grains are also used in preserving meat and apple fruits. Amaranth oil, containing 'squalene' a cosmetic ingredient and skin penetrate, is also used as a lubricant for computer discs.
- Black seeded cultivars are used as cattle feed. Plant parts are also used as pig feed. High forage yields, high protein and low levels of oxalates and nitrates in amaranth offer a good scope for its utilization as a promising forage crop.
- The tribal people use its grains for the treatment of measles and snakebites as well as for foot and mouth diseases of animals. The stem and leaf extracts are used in the treatment of kidney stones. The topopherol fraction of amaranth oil contains important cholesterol lowering agents, some of which could be useful in treating cardiovascular diseases. The plant is also used in piles to purify blood. The leaves are used to relieve chest congestion.

Varietal Development

About 20 species are found as wild and/or cultivated throughout India. A total of 5734 germplasm accessions of Amaranth are present in National Gene Bank (NGB) for long-term conservation. In addition, 57 accessions are cryopreserved at Tissue Culture and Cryopreservation Unit (TCCU), New Delhi. Among them, 40 different species *viz. Amaranthus acutilobus* (3), *A. albus* (4), *A. amora* (6), *A. australis* (2), *A. blitoides* (2), *A. blitum* (29), *A. cannabinus* (5), *A. caudatum* (10), *A. caudatus* (207), *A. caudatus var. albiflorus* (1), *A. caudatus var. atropurpurea* (1), *A. cordatus* (3), *A. crispus* (1), *A. cruentus* (157), *A. deflexus* (2), *A. dubius* (66), *A. edulis* (1), *A. fimbriatus* (2), *A. flavus* (1), *A. floridanus* (2), *A. gangeticus* (Vegetable type) (26), *A. graecizans* (30), *A. hybridus* (86), *A. hypocondriacus* (3141), *A. leucocorpus* (2), *A. lividus* (2), *A. mangostanus* (7), *A. oleraceus* (23), *A. palmeri* (3), *A. paniculatus* (17), *A. polygonoides* (4), *A. powellii* (3), *A. pumilus* (5), *A. retroflexus* (9), *A. rudis* (1), *Amaranthus*. sp. (1351). *A. spinosus* (34), *A. tricolor* (Vegetable type) (422), *A. tristis* (7), *A. viridis* (Vegetable type) (56). Among them 504 accessions are vegetable type amaranths. These genetic materials are available to amaranth breeders for utilization in their breeding programs.

A total of 23 improved varieties were released/notified at the national/ regional level in this crop by the Central Sub-Committee on Crop Standards, Notification and Release of Varieties for Agricultural Crops'/ State Variety Release Committee(S). The details of varieties and year of release are given below.

Varieties for Hills

1. **Annapurna (1984):** This was the first grain type improved variety and was developed at ICAR-NBPGR regional station Shimla as a pure line selection from the material (IC 42258-1) collected from Pauri Garhwal, Uttarakhand. It was recommended for mid and high Himalayan region of India. Its average seed yield is 22.50 q/ha and has high protein content (15%). This variety is drought tolerant and widely adapted.

2. **PRA-1 (1997):** The variety was developed at CoF, UUHF, Ranichauri, Tehri Garwal, Uttarakhand. The variety was selected from Ranichauri germplasm collections (PRA 8801) and released for Uttarakhand state. The average seed yield of the variety is 14.50 q/ha. It has bolder creamish yellow seeds. The seeds have 13-14 % protein and 9.2 % oil content.

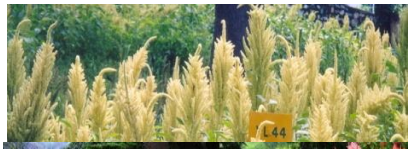
3. **PRA-2 (2000):** The variety was developed at CoF, UUHF, Ranichauri, Tehri Garwal, Uttarakhand from the local material (PRA 9101) of Saonli (Tehri) and released for North- West Himalayan region except J&K. Its average seed yield is 14.5 q/ha. The plants are medium tall (138 cm), with dark green long inflorescence that turns light green at maturity. The seeds have shining cream colour and are medium bold. The variety matures in about 133 days. Inflorescence is compact, cylindrical and profusely branched. The variety has field tolerance to major pests and diseases. The seeds have higher protein (14-15 %) and oil (12%) content as compared to other varieties.

4. **PRA-3 (2003):** It was developed from the cross PRA 8801 x Suvarna at CoF, UUHF, Ranichauri, Tehri Garwal, Uttarakhand and released for North-West Himalayan region except J&K. It was recommended for timely shown, rainfed and low-input conditions of mid and high hill region. The plants are medium tall (139.3 cm) and seeds are medium bold, shining and creamish yellow. It has field tolerance to major pests and

diseases including Rhizoctonia and matures in 135 days. Its average yield is 16.5 q/ha.

5. **Durga (2006):** It was developed through selection form the germplasm 'NIC 22535 (IC35407)' at ICAR-NBPGR regional station Shimla and released for hill areas of North West hill zone comprising states of Himachal Pradesh and Uttranchal. Its average yield is 21.0 q/ha and matures in about 125 days earlier than other released varieties by about 10-15 days. It is medium tall in height with average plant height of 170 cm. It has field tolerance to major diseases and insect / pests. It is tolerant to lodging because of its medium plant height. It has moderate resistance to shattering.

6. **VL Chua 44 (2006):** The variety was developed at ICAR-VPKAS, Almora from Pure line selection from IC 5564 and released for mid and higher hills of Uttarakhand. Its average yield is 13.20 q/ha.



7. **VL Chua 110 (2020):** This variety was developed at ICAR-VPKAS, Almora and released for rainfed organic conditions of Uttarakhand hills. It is a medium duration (116 days) variety with a yield potential of 7-9 q/ha. The grains possess high protein (14.27%), calcium (221.5mg/100 g) and total antioxidant activity (25.88mM/g DW).

Varieties for Plains

1. **Gujarat Amaranth -1 (1991):** The variety was developed at SDAU, SK Nagar by selection from local germplasm and released for Gujarat and Maharashtra state. This was the first improved high yielding variety released for plains. Its average seed yield is 19.5 q/ha. The variety matures in 100-110 days and attains a height of about 2 m. The inflorescence is semi compact and has yellow colour. Seed colour is yellow with test weight of 0.8 gm per 1000 seed. No disease and pest incidence was noticed.

2. **Suvarna (1992):** The variety was developed at UAS, Bangalore as a pureline selection from the introduced material 'Rodale Plus'. The variety was released for peninsular region and its suitability for paddy- fallows in southern states. It is photo insensitive and can be grown throughout the year. It is early in maturity (80-90 days) and has 120-130 cm height. Its average seed yield is 16 q/ha. The plant type is non-lodging and non–pest harboring. It has green leaves, strong stalk and open inflorescence green in colour.

3. **Gujarat Amaranth-2 (2000):** It was developed at SDAU, SK Nagar, Gujarat through mass selection in the local material collected from Rasana village, Banaskantha Dist. and released for Gujarat state. The average yield of the variety is 23 q/ha. It matures in 98 days. The variety is suitable for Rabi season. The foliage is light red with red coloured inflorescence and the seeds are creamish in colour.

4. **KAPILASA (BGA 2) (2005):** The variety was developed through selection from the local cultivar at OUAT, Bhubaneswar and released for plains of Odisha, Tamil Nadu and Karnataka states. Its average seed yield is 13.5 q/ha. It can suitably be grown under rainfed uplands during Kharif and irrigated uplands during Rabi season. It is medium in height (165 cm) and matures on an average in 95 days. It has compact, branched and large inflorescence. The plants are mono-stem and non-lodging type. The variety is resistant to diseases and pests.

5. **Gujarat Amaranth – 3 (2008):** The variety developed at SDAU, SK Nagar, Gujarat as a pure line selection from Vasada -1 -5 and released for Gujarat and Jharkhand state for Rabi season. The variety gives an average seed yield of 12.58 q/ha. The variety has light pink foliage with light red inflorescence and mature in about 95-100 days. The plant with single stem has 130-150 cm height.

6. **RMA 4 (2008):** The variety developed at ARS, Jodhpur Agriculture University Mandor, as a selection from IC035647 and released for Rajasthan, Jharkhand and Odisha state for Rabi season. The variety gave an average seed yield of 13.90 q/ha. The variety has green foliage with light green inflorescence and matures in about 122 days. The plant has a height of about 1 m with about 50 cm long inflorescence.

7. **KBGA-1 (2008):** The variety developed at UAS Bengaluru and is a pure line selection from IC41998 and released for Southern Karnataka in Kharif season. The variety gives an average seed yield of 12-14 q/ha. The variety has Purple inflorescence and mature in about 85 days.

8. **RMA-7 (2010):** The variety developed at ARS, Jodhpur Agriculture University Mandor, as a selection from RU-7-SPS-7 and released for Rajasthan, Gujarat, Maharashtra, Haryana and Delhi and Odisha state for Rabi season. The variety gave an average seed yield of 14.03 q/ha. The variety has green foliage with light green inflorescence and matures in about 126 days.

9. **Phule Kartiki (2010):** The variety developed at MPKV, Rahuri and released for Maharashtra state for Rabi season. The variety gave an average seed yield of 15.00 q/ha with medium maturity.

10. **KBGA-4 (2017):** The variety developed at UAS Bengaluru and is a pure line selection from GA-2 and released for Karnataka States. The variety gives an average seed yield of 20-22 q/ha. The variety has purple inflorescence and mature in about 90 days. The plant with Monostem has 140 cm height.

11. **Chhattisgarh Rajgira (2017):** The variety developed at IGKV, Raipur and is a pure line selection from IC618487. It has been recommended for release in Chhattisgarh State in Rabi season. The variety gives an average seed yield of 13.5 q/ha. The variety has dark green stature, early maturity (115 days) and content high protein (11.70%). The plant with Monostem has 100 cm average height.

12. **Suvadra (BGA 4-9) (2020):** The variety was developed at OUAT, Bhubaneswar. Average yield of 17-18 q/ha with medium maturity (125 days), single stem and non-lodging. Purple red colour stem with medium height (120 cm). Creamy white seed with protein content (11.4%) and oil (7.1%). The variety was released for the states of Odisha, Chhattisgarh, Maharashtra, Bihar and Gujarat for cultivation during Rabi.

13. **Gujarat Amaranth-4 (2019):** The variety developed at SDAU, SK Nagar, Gujarat and is a pure line selection from IC005574. It has been recommended for release for adaptation in peninsular India in Rabi season. The variety gives an average seed yield of 16.45 q/ha. The variety has light yellow with reddish dot red inflorescence and mature in about 90 days. The plant with Monostem has 170 cm height.

14. **Gujarat Amaranth–5 (2019):** The variety developed at SDAU, SK Nagar, Gujarat and is a pure line selection from IC000385. It has been recommended for release in Gujarat, Rajasthan, Maharashtra and Jharkhand adaptation in Rabi season. The variety gives an average seed yield of 19.02 q/ha. The variety has light red inflorescence and mature in about 103-150 days. The plant with Monoester has 184 cm height.

15. Gujarat Amaranth–6 (2019): The variety developed at SDAU, SK Nagar, Gujarat and is a pure line selection from IC631711. It has been recommended for release in Gujarat State in Rabi season. The variety gives an average seed yield of 18.84 q/ha. The variety has green stature, early maturity (105 days) and non-lodging, creamy white bold seeded (8.06 g/10ml) and content high protein (11.52%). The plant with Monostem has 143.30 cm average height.

16. KBGA-15 (2021): The varieties were developed at UAS, Bengaluru and released for cultivation in Easter Dry Zone (Zone-V) and Southern Dry Zone (Zone-VI) of Karnataka State. The variety gives an average seed yield of 16-18 q/ha rainfed condition. The variety has pink mix green inflorescence in colour and mature in about 90-95 days.

Summary

The green revolution during 60's gave us a great relief on food production aspect but continued mono-cropping systems in agriculture and cereal based diets (wheat–rice) led to negative effects on soil as well as human health. The soils become sick due to micronutrients deficiency. The human beings become prone to several chronic diseases as some of the minor crops which were integral components of diet in the past have been replaced by wheat and rice. Grain amaranth (*Amaranthus hypochondriacus* L.), a minor and underutilized crop, has become a life support species due to its potential in extreme environmental situations and threatened habitats, having genetic tolerance to survive under harsh conditions and possessing qualities of nutritional and/or industrial importance for a variety of purposes for the present as well as future needs of mankind. Improved varieties have been released/ identified at national/ regional level in grain amaranth by Central Variety Release Committee based on their performance in multi-locations under various coordinated trials. The performance of the variety varies widely over environments due to the genetics of the variety. Only a stable genotype can express its genetic potentiality and for that it is necessary to identify stable genotypes for wide adaption across environments. The information on varieties and environments allows for a better measure of evaluating varietal stability. The varietal improvement is needed to increase the yield potential of this crop.