IMPROVED VARIETIES AND CULTIVATION PRACTICES OF GRAIN AMARANTH

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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 and minerals. Amaranths belong to the family *Amaranthaceae* and are referred as pseudo-cereal to distinguish them from true cereals which belong to family Gramineae / Poaceae. Amaranths are erect, annual, 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 lustre and are rich in proteins and minerals. The plants vary from branched to unbranched types. There are about 75 species of 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. The useful species of grain amaranth are given in Table 1.

Table 1. The useful species of grain amaranth

S. No.	*Type*	*Species*
1.	Grain type	*Amaranthus hypochondriacus* (L.), *A. cruentus, A. caudantus, A. edulis,*
2.	Vegetable type	*A. dubius, A. bolitum, A. viridis, A. tricolor*
3.	Vegetable and fodder type (Dual purpose)	*A. hybridus*
4.	Wild type	*A. spinosus*

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. 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, Chattisgarh, Maharashtra, Gujarat, Orissa, Karnataka, Kerala and Tamil Nadu.

The exact information about

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the statistics on area and production in India is lacking. However, it is estimated to be grown in about 40-50 thousand ha. 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 on account of water scarcity. At present the area in this district alone is estimated to be around 6000 ha and the grain market at Palanpur receives about 6 – 10 thousand tonnes grains annually.

NUTRITIONAL VALUE

This crop possesses an exceptionally high nutritive value with high content of protein, lipids and minerals (Table 2) as well as balanced composition of essential amino acids (Table 3). The tiny seeds of grain amaranths compare favourably with maize and other true cereals in nutritional value and yield. Amaranth has very high nutritional value due to its protein quality and other nutrients. 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. 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 into 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. Quality traits of released varieties of grain amaranth are given in Table 4.

Table 2. Comparative food value of grain amaranth with other cereals

Crop	*Protein (%)*	*Carbohydrates (%)*	*Lipids (%)*	*Minerals (%)*
Amaranth	16.0	62.0	8.0	3.0
Wheat	12.0	69.0	1.7	2.7
Rice	6.7	78.0	0.3	0.3
Maize	11.0	66.0	3.5	1.1
Barley	11.0	69.0	1.3	1.9

Table 3. Amino acid composition of grain amaranth with other cereals (g/100 g protein)

Amino acids	*Amaranth*	*Wheat*	*Rice*	*Maize*	*Barley*
Lysine	5.0	2.8	3.8	2.9	3.0
Methionine	4.0	1.5	2.3	3.4	3.2
Cystein	4.0	2.2	1.4	3.4	3.7
Isoleucine	3.0	3.3	3.8	4.1	4.0
Leucine	4.7	6.7	3.2	13.0	7.5

Table 4. Quality parameters (%) of released varieties of grain amaranth

Variety	*Protein*	*Lysine*	*Starch*
Annapurna	12.20	5.40	62.10
GA-1	13.23	4.83	-
GA-2	13.70	4.50	62.40
Suvarna	12.57	5.23	58.90
PRA-1	13.10	4.80	-
PRA-2	15.00	4.90	60.20
PRA-3 (9401)	13.60	5.60	60.20
IC-35407 (Durga)	14.10	4.80	55.80
BGA-2	13.57	4.87	-

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 penetrant, 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 extract is 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.

VARIETIES FOR HILLS

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

2. PRA-1 (PRA 8801): The variety was developed at G.B.Pant University of Agriculture & Technology Hill Campus, Ranichauri, Tehri Garwal and was released in 1997 for Uttarakhand hills by State Variety Release Committee. The variety was selected from Ranichauri germplasm collections. 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 (PRA 9101): The variety was developed at G.B. Pant University of Agriculture & Technology, Hill Campus, Ranichauri, Tehri Garwal from the local material of Saonli (Tehri). The variety was released in 2000 for North-West Himalayan region excluding Jammu & Kashmir. The variety gives an average seed yield of 14.5 q/ha. The plants are medium tall (138cm), 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 (PRA 9401) : It was developed from the cross PRA 8801 x Suvarna at G.B.

Pant University of Agriculture & Technology, Hill Campus, Ranichauri, Tehri Garwal and released in 2003 for North-West Himalayan region except Jammu & Kashmir. It is recommended for timely sown, rainfed and low-input conditions of mid and high hill region. The plants are medium tall (139.3 cm). The inflorescence is long, light green and semi-compact. The seeds are medium bold, shining and creamish yellow. The variety, on an average, matures in 135 days with variation across locations and altitude. It has field tolerance to major pests and diseases including Rhizoctonia. Average seed yield of the variety is 16.5 q/ha.

5. Durga (IC35407): It was developed through selection form the germplasm 'NIC 22535' at NBPGR Regional Station, Shimla and was released in 2006 for hill areas of North West hill zone comprising states of Himachal Pradesh and Uttarakhand. Its average seed yield is 21.0 q/ha. The variety matures in about 125 days and is earlier than other released varieties by about 10-15 days. It is recommended for rainfed and low to medium input conditions in mid to high hill regions of India. It is medium tall in height with average plant height of 170 cm. Inflorescence is erect and compact type with mosaic of yellow and red colour. Foliage turns yellowish at maturity. 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. The variety is responsive to fertilizer doze of N up to 80 kg/ha. For getting pure seed of the variety, the farmers should maintain an isolation distance of about 200 m as it is often cross pollinated.

VARIETIES FOR PLAINS

1. Gujarat Amaranth -1 (GA-1) : Recommended for cultivation in states of Gujarat and Maharashtra, the variety was developed at SDAU, SK Nagar by selection from local germplasm and was released in 1991. This was the first improved high yielding variety released for cultivation in 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. The recommended sowing time for this variety is first fortnight of November with seed rate of 0.75 kg/ha and spacing 50 cm x 15 cm. Glomerules are medium long and the apex glomerule is slightly bent. Seed colour is yellow with test weight of 0.8 gm per 1000 seed. No disease and pest incidence was noticed during the years of experimentation.

2. Suvarna : Recommended for cultivation in peninsular region (Karnataka, Orissa Maharashtra, Tamil Nadu and Gujarat) of the country, the variety was developed at UAS, Bangalooru as a pureline selection from the introduced material 'Rodale Plus'. The variety was released in 1992 for its suitability for paddy-fallows in southern states of the country. 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 harbouring. It has green leaves, strong stalk and open inflorescence green in colour. The anthesis occurs during early hours at around 6 - 8 a.m and thus avoids the bee visit. This helps in maintenance of its seed purity unlike other varieties that bloom during late hours in the morning and cross pollination is enhanced. The best results are

obtained when grown at 45cm x 15 cm spacing and a fertilizer doze of N:P:K @ 40:40:20 kg/ha is applied.

3. Gujarat Amaranth-2 (GA-2): It was developed at SDAU, SK Nagar, Gujarat through mass selection from the local material collected from village Rasana, Dist. Banaskantha, Gujarat. The variety was released in 2000 for Gujarat state. The average seed yield of the variety is 23 q/ha. It matures, on an average, in 98 days and is earlier in maturity than GA-1 by 10-12 days. The plants are tall having a height of about 180 cm. The variety is suitable for Rabi season. The foliage is light red with red coloured inflorescence. The seeds are creamish in colour with seed weight of 0.8 g/1000 seeds.

4. KAPILASA (BGA-2): The variety was developed through selection from the local cultivar at Orissa University of Agricultural and Technology, Bhubaneswar and was released in 2005 for plains of Orissa, Tamil Nadu and Karnataka states. Its averge 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 unbranched stem is non-lodging type. Leaves are green with whitish yellow inflorescence. The variety is resistant to diseases and pests.

5. Gujarat Amaranth – 3 (GA-3): The variety developed at SDAU, SK Nagar, Gujarat and tested as SKNK-21 is a pure line selection from Vasada -1 -5. The variety was identified for its release at the Annual Group Meet of All India Coordinated Research Network on Underutilized Crops during 2008. It has been recommended for release in states of Gujarat and Jharkhand for cultivation in 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. The creamy white seeds have 0.80 g as their 1000-seed weight.

6. RMA 4: The variety developed at Agricultural Research Station, Rajasthan Agriculture University, Mandor, Jodhpur is a selection from IC 35647. It was identified for release at the Annual Group Meet of All India Coordinated Research Network on Underutilized Crops during 2008. It has been recommended for release in states of Rajasthan, Jharkhand and Orissa for its cultivation in 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 one metre with about 50 cm long inflorescence. The creamy white seeds have 7.75 g weight of 10 ml volume.

CULTIVATION PRACTICES

Selection of site: Well drained soils with near neutral pH (6.00-8.00) are best suited for cultivation of grain amaranth. Amaranth being susceptible to acidic and alkaline conditions, the soils and waters affected by salts should not be used for its cultivation.

Field preparation: Grain amaranth being a small seeded crop requires a fine seed bed for proper seed-soil contact and good germination. For this purpose, soil is turned with a mould board plough prior to onset of rains. This is followed by two to three ploughings and plankings on receipt of soaking rains. At the time of sowing, the field must have fine grain structure, adequate moisture and should be free from weeds.

Sowing time: In hills, the crop is generally sown in the months of May-June soon after onset of monsoon. However, in plains it can be sown either in Rabi or Kharif season. But, generally it is cultivated in Rabi season and is sown in months of October – November.

Crop spacing : Sowing the seeds 2 cm. deep in rows 45 cm.

apart with 10-15 cm distance between plants have been observed to give good yields. Thinning / gap filling should be done after two weeks of germination to maintain proper plant to plant distance.

Table 5. Suitable intercrop systems and appropriate row ratios for mixed cropping of grain amaranth

S. No.	*Intercrop system*	*Appropriate row ratio*	*Region for which recommended*
1.	French bean + amaranth	2:1	Hill regions
2.	Rice bean + amaranth	2:1	Hill regions
3.	Ragi + amaranth	6:2	Karnataka
4.	Groundnut + amaranth	6:1	Karnataka
5.	Pigeonpea (90 cm row to row distance) + amaranth	1:2	Karnataka, Orissa
6.	Pigeonpea (75 cm row to row distance) + amaranth	1:1	Orissa

Seed rate : A seed rate of 1.5 kg/ha is enough for obtaining desired plant stand. If the rains are delayed in Kharif and irrigation is not available in time during Rabi season, dry sowing can also be done. The seeds will germinate after downpour or as and when irrigation is given.

Fertilizer requirement: The crop gives a good response up to fertilizer application of 60:40:20 kg N:P:K /ha. Half of N with full dose of P and K should be given as basal application. Remaining half dose of N can be given after 30 days of sowing. In light soils of Gujarat, additional application of FYM @ 5 tons / ha is recommended. In boron deficient soils of Orissa, soil application of boron @ 1 kg/ha or foliar spray of 0.33% boron increases grain yield by 8-10 %. Substitution of 25 % N by FYM or Neem Cake results in higher grain yield as compared to application of chemical fertilizer alone.

Weed Control: Weeds compete with the crop for space, light, nutrients and moisture and can cause considerable loss if not controlled in time. The period between 20 to 50 days after sowing (DAS) has been observed to be critical for crop-weed competition in grain amaranth. Therefore, two hand weedings at 25 and 40 DAS are recommended for effective weed control.

Irrigation: Grain amaranth is mostly grown as rainfed crop in the hills during Kharif season. However, in plains, when grown during Rabi season, it has been found to respond favourably to application of irrigation. Optimal irrigation schedule for grain amaranth has been worked out to be 0.6 IW/ CPE in northern plains and 0.8 IW/CPE in Gujarat. Depending upon these conditions about 3-4 irrigations are sufficient for getting good yield in amaranth.

Suitable intercrop systems: Amaranth is usually grown in crop mixtures. Intercropping amaranth with French bean, rice bean, ragi, groundnut and pigeonpea have been found profitable. Simply mixing seeds of different crops and broadcasting may not give desired results. However, to obtain maximum advantage from the mixed crop and to facilitate separate harvesting of component crops, the crops should be sown in different lines and in appropriate row ratios. In hills, intercropping French bean and amaranth in 2:1 ratio and applying fertilizer doze recommended for French bean only (N:P:K @ 20 : 40:20 kg/ha) resulted in highest B:C ratio (2.57). Suitable intercrop systems and row ratios for intercropping grain amaranth in different regions are given in Table 5.

Plant protection: There is no report of serious problem of pests and diseases in this crop. However, leaf head blight, white rust, damping off, mycoplasma and viral diseases may affect this crop. Among pests, leaf webber, caterpillars, aphids, blister beetle, flea beetle, bugs, stem weevil and stem borer have been reported to affect this crop. Use of disease resistant varieties, spray of fungicides (Dithane Z-78 for blight, Karathane for white rust and Bavistin for damping off) @ 0.1%,

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use of Lindane 10% @ 25 kg/ha dust for caterpillars, beetles and bugs, Phorate 10 G @3.5 kg/ha for stem weevils and borer and Malathion for controlling aphids are recommended.

Yield : The average productivity of grain amaranth is estimated around 16 q/ha. The grain amaranth yield upto 40 q/ha have been obtained in hill regions and 25 q/ha in plain regions. There is a ample scope for increasing the yield of grain amaranth in India through efficient agronomic management of the crop.

SUMMARY

By adopting improved technologies and varieties as described above, the yield of grain amaranth in hills and plains can be substantially increased. It will not only ameliorate economic condition of the farmers dwelling in the hills and plains, but will also enhance the availability of nutritious food to check malnutrition in human beings.