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Improved Varieties, Agro-Techniques, Potential Uses of Grain Amaranth Increase the Yield and Area in India and Enhance the Availability of Nutritious Food in Human Beings

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Abstract

Grain amaranth, a minor and underutilized potential 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. On the other hand, the cultivation of grain amaranth is restricted to remote areas in different agro-ecological regions, mainly by the poor farming communities who have limited access to modern agro-inputs and well-organized marketing structure. Now-a-days, this crop is being promoted globally as a nutritive food crop or potential crop of the future. This crop is still not in the mainstream cultivation practices in India and the world. As the planet is expecting massive increase in human population and global climate change, we firmly believe that this widely distributed, ancient, protein-rich grain amaranth has a potential to augment our food system and demand in future. By adopting improved varieties and agro-techniques, the yield of grain amaranth in both hills and plains can be substantially increased.

Keywords: Gluten-free, Pseudocereal grain, Rajgira, Value added product, AICRN on Potential Crops,

Introduction:

Grain amaranth, an edible pseudocereal is now a crop of interest because of its higher and quality protein and high micronutrients contents. Grain amaranth possess C_4 pathway, which confers physiological advantage of high rate of photosynthesis. This crop can be grown even in hospitable environments. The three principal species that are considered for grain production include: *Amaranth hypochondriacus, A. cruentus and A. caudatus.* In some of the Indian languages, it is known as *rajgira* ("king of seeds") in Gujarati, *ramdana* ("seed sent by

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god") in Bihar, Odisha and Uttar Pradesh, *Chuka* in Bengal, *Kalaghesa, chumera* and *ganhar* in central India and *Bathu* in HP etc.

Fig. 1: Cultivation of grain amaranth in Banaskantha district, Gujarat

Amaranthus are widely distributed throughout the Old and New World (Sauer, 1967). In Asia-Pacific regions covering India, China, Manchuria, Nepal, Bhutan, Afghanistan, Indonesia, Japan, Thailand and Israel, this crop is cultivated as minor crop. In India, grain amaranth is primarily cultivated in hill regions but of late in 1990s, its cultivation gained momentum in Central and Western Plateau regions of India. However, it is estimated that the crop is grown in about 40-50 thousand ha in India.

Grain amaranth cultivation in Gujarat has gained momentum as compared to other parts of the country. In Gujarat, there has been remarkable increase in the area, production and productivity of Rajgira during last 10 years. The area under this crop is increasing, particularly in Banaskantha and Kheda districts fig. 1 where this crop replaces wheat and potato because of water scarcity. The cultivation area under this crop in Gujarat is about >12,000 ha (Rabi 2017-18). In Gujarat, Palanpur APMC market of Banaskantha district is one of the biggest markets for amaranths grain selling /purchasing, from where the grain is exported to other parts of the country. It is unlikely that the area under grain amaranth would increase significantly owing to its limited usage as a food crop.

Nutritional Value

This crop posses an exceptionally high nutritive value with high content of protein, lipids and minerals (Bhagmal 1994) as well as balance composition of essential amino acids (Saunders and Becker, 1983; Joshi and Rana, 1991). 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 β-carotene and thus can help in circumventing iron and vitamin

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A deficiency. Presence of higher amount of folic acid also helps in increasing the blood hemoglobin 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 (Dua *et al.*, 2009). 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)* fig. 2. 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 (Joshi and Rana, 1991).

Fig. 2: Laddoo prepared by AICRN on Potential Crops, UAS, Bengaluru

- Amaranth oil, containing 'squalene' a cosmetic ingredient and skin penetrate, is also used as a lubricant for computer discs (Sanchez-Marroquin, 1983).
- 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 (Ahuja *et al.*, 1991).
- 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.

Varietal Development

Research on grain amaranth is undertaken through All India Coordinated Research Network on Potential Crops (formerly Under-Utilized crops) and more than 1000 germplasm

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accessions have been evaluated at multi-locations since the inception of programme (Raiger *et al.*, 2022). Out of these accession, 25 varieties have been developed and released for both hill and plain region through selection. The details of varieties and year of release are given in Table 1, fig. 3-4.

Table 1. List of varieties released under AICRN on Potential Crops.

S. No.	Varieties	Year	Av. yield (q/ha)	Protein (%)	Oil (%)	Lysine (g/100g Protein)	Recommended areas
1	Annapurna	1984	22.50	12.20	7.53	5.40	Mid and high Himalayan region of India
2	GA-1	1991	19.50	13.23	8.20	4.83	Gujarat, Maharashtra
3	Suvarna	1992	16.00	12.57	7.61	5.23	Peninsular region (Karnataka, Orissa) Gujarat
4	PRA-1	1997	14.50	13.10		4.80	Uttaranchal hills
5	PRA-2	2001	14.50	15.00	6.94	4.90	North- West Himalayan region except J&K
6	GA-2	2002	15.50	13.70	7.31	4.50	Gujarat state
7	PRA-3	2003	16.50	13.60	6.36	5.60	North- West Himalayan region except J&K
8	BGA-2	2006	13.26	13.57	7.54	4.87	Karnataka, Orissa and Tamil Nadu
9	Durga	2006	21.00	14.10	7.38	4.80	North west hill zone comprising states of Himachal Pradesh Uttaranchal and J &K
10	VL Chua 44	2006	13.20	11.80	6.30	–	Mid and higher hills of Uttaranchal
11	GA-3	2008	12.58	12.43	–	–	States of Gujarat and Jharkhand
12	RMA- 4	2008	13.90	12.38	–	–	States of Rajasthan, Jharkhand and Orissa

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13	RMA-7	2010	14.66	12.34	7.24	–	Rajasthan, Gujarat, Orissa, Maharashtra, Haryana, Delhi states
14	KBGA-1	2012	15.00	12.10	7.20	–	Karnataka
15	Phule kartiki	2012	15.00	13.8	–	5.20	Maharashtra
16	Prachi	2015	11.60	15.30	–	–	Odisha state
17	Ruchi	2015	11.90	12.30	–	–	Odisha state
18	Chhattisgarh Rajgira-1	2017	14.00	11.70	6.50	–	Chhattisgarh
19	KBGA-4	2017	21.00	12.30	6.80	–	Karnataka
20	Suvadra	2018	17.50	11.40	7.10	–	Odisha, Chhattisgarh, Jharkhand, Maharashtra and Gujarat
21	GA-4	2020	16.45	12.04	7.20	–	Karnataka State
22	GA-5	2020	19.02	11.85	7.71	–	Gujarat, Rajasthan, Maharashtra and Jharkhand State
23	GA-6	2020	18.50	11.52	7.80	8.58	Gujarat State
24	VL Chua-110	2020	13.00	14.27	–	6.43	Uttarakhand Hills
25	KBAG-15	2021	2.00	12.30	8.71	–	Karnataka

Fig. 3: VL Chua 110: for rainfed organic ecology of Uttarakhand Hill

Fig. 4: Suvadra: Medium maturity and high yielding

Fig. 5: GA5: Field resistant to major diseases and pests

Fig. 6: Suvarna: Early maturing

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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.
- **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 weeding at 25 and 40 DAS or pre-emergent

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application of Oxyflurofen @ 50 g/ha with one hand weeding at five weeks after sowing 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 irrigations. 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.

Fig. 7: Prominent intercropping system in Gujarat (Grain amaranth+ gram 1:1)

Suitable intercrop systems:

Amaranth is usually grown in crop mixtures. Suitable intercrop systems and row ratios for intercropping grain amaranth in different regions have been found profitable and given in table 2 & fig. 7.

Table 2. Suitable intercrop systems of grain amaranth (Raiger *et al.*, 2009)

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 + amaranth	1:2	Karnataka, Orissa
6.	Pigeonpea + amaranth	1:1	Orissa
7.	Grain amaranth + Gram	1:1	Gujarat

Plant protection:

There is no report of serious problem for 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

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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%, 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 an ample scope for increasing the yield of grain amaranth in India through efficient agronomic management of the crop.

Amaranth Based Value Added Products:

Globally the eminence of nutritional security has become increasingly dependent on only few plant species. Among these the grain amaranth have promising economic value especially with respect to nutritional and medicinal traits. This crop is traditionally used in different food preparations as staple diets in most of the tribal regions of India. There is tremendous scope for these crops to be used as supplements and to develop value added products with high nutritive value. The use of this crop would result in product competitiveness, of location specific traditional value added products (Fig. 8).

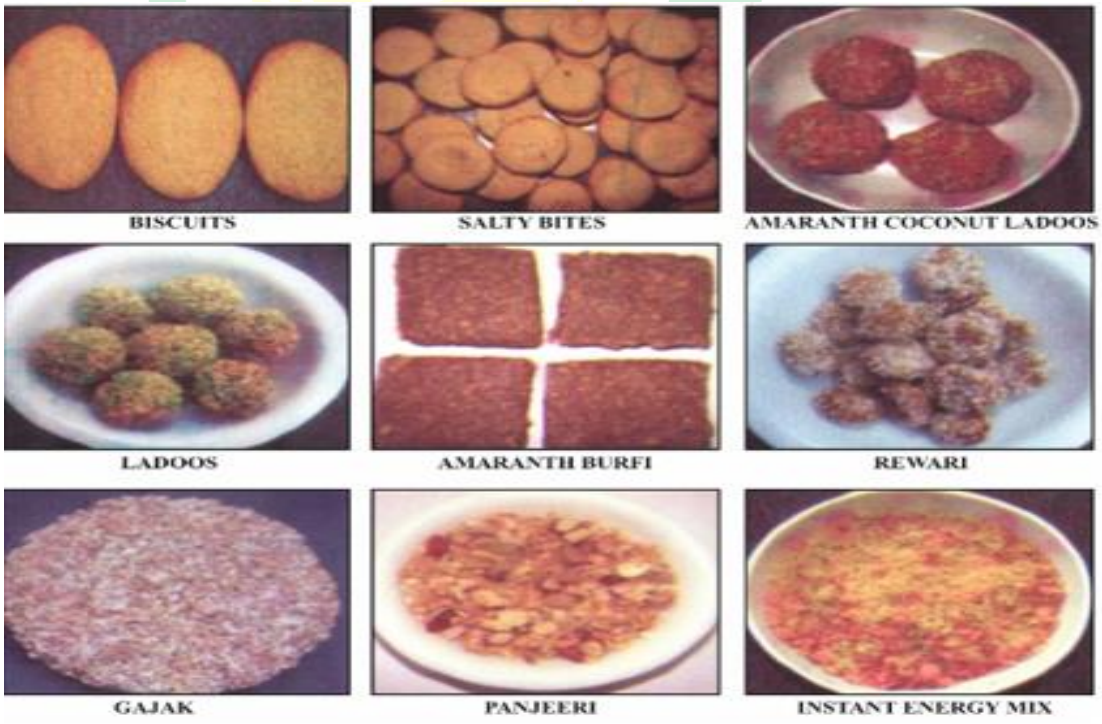

Fig. 8: Value added products of Grain amaranth

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Amaranth/ Rajgira too is mostly rolled and popped and can be used in *museli*, granola bars, *chapati*,*Panjiri*, Cakes, *Chikki*, malt/beverages, *Barfi*, *Laddu*, *Upama*, salty biscuits, ready to eat breakfast cereals, etc. Recepies of various value added products from grain amaranth were developed and standardized at Department of Food Science, Nutrition and Technology, College of Home science, CSK Himachal Pradesh *Krishi Visvavidyalaya*, Palampur; University of Agriculture, Gandhi *Krishi Vigyana Kendra* (GKVK), Bangalore; Orissa University of Agriculture and Technology, Bhubaneshwar; Indira Gandhi *Krishi Vishvidyalaya*, Raipur, Chhattisgarh India, for the utilization of amaranth. Keeping in view the great significance of grain amaranth, there is a scope to exploit potential to promote entrepreneurships in various food items at household and cottage industry level.

Summary

Amaranth is considered as a staple Indian diet and is described as a "superfood" because of its high protein content and well-balanced amino acid profile. In terms of nutrient content, amaranth surpasses many staple crops (cereals) such as rice, corn, and wheat. Additionally, lysine content is twice as much than in rice and thrice as much than in corn. Along with desirable agronomic traits, this crop has been largely applauded for its gluten-free nature. Not only it benefits the vegan and gluten allergy human beings, but it also has the potential to supply high-quality proteins and at the same time provides antimicrobial activities in the packaged food items. Despite all these properties, this crop is still not in the mainstream cultivation practices in India and the world. By adopting improved varieties and agro-techniques as described above, the yield of grain amaranth in both 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.

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