Saubhik Das

Amaranthus: A Promising Crop of Future

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Preface

Pseudocereals are promising crops for coming decades keeping in view the global food security. Amaranths are a leading group of plants among the pseudocereals that have the great potentiality to prevent malnutrition especially in the low-income food-deficient countries. Though its cultivation and use as food grains have great antiquity, but later its cultivation was ignored by a larger section of people of the world. It lagged behind the conventional cereal crops in spite of being nutritionally very much competitive to those. In the last few decades, the nutritive potentialities and other unique features of amaranths have been rediscovered in different corners of the world. Research done so far on amaranths has surfaced its unique and unparallel nutritive value, wide adaptability, herbicide resistance property and vast germplasm variability. Its germplasm variability has opened up a new avenue to evolve much improved varieties or cultivars. Little efforts have been devoted to improve its genetic background by applying biotechnological methods. But that yielded significant achievements. Keeping in view its tremendous potentiality to become a super crop of coming decades, much more attention is to be given to it especially when the conventional crops are overburdened with a task to feed the huge world population. To increase the food production at a global level and at a sustainable basis, the importance of amaranths cannot be ignored.

In this book, attempts have been made to accumulate updated information, significant research achievements and knowledge about amaranths also to revive interest about amaranths and to explore them comprehensively.

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The effort devoted in this book will be successful if the book gets recognition and appreciation. The author welcomes relevant comments and suggestions for future improvement of this book.

Taki, West Bengal, India Saubhik Das

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1 Introduction

1.1 General

Global food security and struggle against malnutrition are going to face a strong challenge in the coming decades from population outburst specially in the developing and Third World countries. Only a handful of crops have to feed nearly nine billion people all over the world by 2030 as against 5.7 billion at present. The condition is much more threatening due to the declining number of plant species and genetic erosion of overexploited plant species. Scientists all over the world are engaged in exploring the plant biodiversity to broaden the crop list. There are many neglected and underutilised species which are capable of satisfying the demand for food, nutrition and energy. They can function as alternative crops, not competitive to other major crops, and can be adapted to fragile environment and marginal areas needing least agronomic requirements.

1.2 Agricultural Development and Global Food Security

Food is one of the basic needs of human being. The bulk of the food consumed in the world are procured from a very limited number of crop species. Today by and large, 25–30 food-yielding species supply food to mankind, viz. wheat, rice, maize, barley, oats, sorghum, millets, soybean, bean, pea, chickpea, peanut, banana, citrus, tomato, sugarcane, cassava, potato, sweet potato, yams and five oil seed types and a few beverages (Harlan 1975), of which only three crop types, viz. rice, wheat and maize, supply 60 % of food requirements for the world human population. Though over 7000 species either partly or fully domesticated have been used so far from time to time for food production, today only 30 species are bearing the herculean responsibility of providing 95 % of the huge world food requirements. Many of the neglected and underutilised species are of great significance as a source of food in low-income food-deficient countries (LIFDCs). They are extremely important because of their wide adaptability to the marginal areas and contribution of a significant part of the local diet with useful nutritional supplements. In comparison with major crops, these neglected and underutilised species require relatively low input and therefore help in sustaining agricultural production. These regional traditional crops are often low yielding and are not competitive to conventional major crops, even though many of them have the potential to become economically viable. Very often narrow genetic diversities in important agronomic traits as well as lack of genetic improvements prevent the development of these crops. Other constrains include lack of adequate knowledge on the taxonomic delimitation, the genetics of agronomic and quality traits and reproductive biology.

Many plant species with significant food and/or industrial value are yet to be utilised properly due to lack of appropriate and adequate

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programmes for their evaluation and development and remained underutilised. Some of them have been so neglected and erosion of their gene pool is so severe that they are often considered as 'lost crops'. A vast majority of these plants have the capability to meet the increasing demand for food and nutrition, healthcare, medicine and industrial needs. Many of these species are involved in traditional localised farming especially in marginal remote areas, and quite often these crops act as life-savers for millions of poor people in the regions where food security and malnutrition are a problem. The rural community knows very well the cultivation practices of the underutilised crops and prepare food from them and use them in their daily life, for health care, shelter, forage and fuel particularly during drought, famine and the dry seasons (Campbell 1987). These crops include cereal, pseudocereals, fruits and nuts, pulses, vegetables, root and tubers, oilseeds and other industrial, forage and fodder species.

Global food security and economic growth is certainly going to face a stiff challenge in the coming few decades due to population outburst especially in the developing and Third World countries. In an estimate it appears that nearly 1.2 billion people in the world are not lucky enough to get adequate food to meet their daily nutritional requirement and a further 2 billion people are deficient in one or more micronutrients (Azam-Ali and Battcock 2002). The scale of food shortage has been estimated by the Food and Agriculture Organization; Jacques Diouf, its secretary general, says that 800 million people in the world (20 % of the population of developing countries and up to 37 % of sub-Saharan Africa) suffer from shortage of food, and 192 million children have chronic malnutrition. By 2030 the humanity has to perform a task of feeding 9 billion people as against 5.7 billion at present. Nearly 30 % of the total population of Africa is suffering from chronic hunger and malnutrition which compelled the stakeholders in and outside the region to look into possible measures to solve food crisis. The gradually emerging threat of worldwide food shortage compelled the US National Academy of Science (NAS) to issue reports on underutilised tropical plants with promising economic value (1975). In recent times NAS issued further reports (e.g. NAS 1989, 1996) and FAO issued many (FAO 1988; Hernandez Bermejo and Leon 1994).

An autonomous international scientific organisation, International Plant Genetic Resources Institute (IPGRI), was established by the Consultative Group on International Agricultural Research (CGIAR) in 1994, and it is situated in Rome, Italy, at the Food and Agriculture Organization of the United Nations. The prime role of IPGRI is to monitor research activity and to promote and coordinate an international network of plant genetic resource, germplasm management conservation, evaluation, documentation and utilisation of useful plant germplasm globally and also the collection and exchange of plant genetic resources. The functioning of IPGRI and other such institutes is monitored by CGIAR which was established in 1972. The joint efforts of Food and Agriculture Organization (FAO), the World Bank and United Nations Development Programme (UNDP) resulted in the creation of CGIAR to establish international research institutes and subsequently to look after their progress.

Global food security and economic growth is now being threatened by declining number of plant species. This decline has placed the future supply of food and rural income at risk. IPGRI has succeeded in promoting greater awareness regarding the important role that minor crops can play in securing and safeguarding the livelihood of people all over the world. Ethnobotanical surveys confirm the presence of hundred of such crops in many countries and different remote corners of the globe that represent a plentiful treasure of agro-biodiversity. Such underutilised mainly ethnic crops can play a vital role to improve income, food security and nutrition. The development of agriculture and food security depends partly on our ability to extend the agricultural species range in an effective and sustainable manner. This requires finding of ways and means to protect and enhance cultivation of the locally important species so that they can be employed more widely in agriculture and environment management and finding of ways to explore the use of local crops in order to tap the hidden potential contained in them. Today global food security has become increasingly dependent on few conventional crops causing their over-exploitation. Even if mankind has used more than 10,000 edible species since the prehistoric period, today only 150 plant species are commercialised globally in a significant scale, 12 of which are supposed to provide approximately 80 % dietary energy from plants and only four plant types, viz. rice, wheat, maize and potato are supposed to supply over 60 % of the global requirements for protein and calories. Moreover the gradual decrease of the crop varieties are increasingly threatening the future supply of food and rural income and this has compelled research organisations and scientists worldwide to retrieve, research and disseminate the knowledge regarding production and utilization of neglected, underutilised new plant species or the so-called alternative crop (FAO 1996a, b, c, 2005).

1.3 Underutilised Crop

Underutilised crops can be defined as a class of crop that once grown more rapidly and intensely but lagged behind the conventional major crops in terms of cultivation and use for variety of agronomic, genetic, economic and cultural reasons. They are not properly utilised though not competitive with other crops. Neglected crops appear to be synonymous with underutilised crops. But neglected crops are those crops which are grown mainly in their centre of origin by traditional farmers for local communities and are ill documented and neglected for research and conservation. The benefits and features of these plants are as follows:

1. They are of local importance in consumption and production system.
2. They can grow well in fragile environment and help to stabilise the agroecosystem particularly in arid, semiarid, mountainous locality and tropical forest. They are virtually adapted to any environmental condition, soil types and specialised agro-ecological niche. They can tolerate difficult conditions and environment stresses.
3. Regarding achievement of success in various social objectives like poverty elimination and generation of employment and income opportunities in both rural and urban environment, they have a great role to play.
4. For the sustenance of livelihood through safeguarding food security and widening food basket, their role cannot be ignored.
5. They are the rich source of nutrients and can add nutrients to the diet. These nutrient-enriched foods are convenient for low-income people group.
6. They provide a wide range of crop species to meet new market demands.
7. They have attracted attention of the National Agriculture and Biodiversity Corporation policies, researches and development.
8. They are cultivated and utilised based on indigenous knowledge.
9. They are scarcely represented in ‘ex situ’ collection.
10. They are represented by ecotypes/or landraces.

2 Pseudocereals: An Efficient Food Supplement

2.1 General

Pseudocereals are defined as fruits or seeds of non-grass species that are consumed in very similar way as cereals. Pseudocereals are effective supplements to conventional cereals. The protein contents of pseudocereals like quinoa, amaranths and buckwheat are much higher than cereals, and the quality of proteins is also much improved containing higher amount of lysine which is limiting in cereals. From the angle of digestibility, bioavailability, available lysine and net protein utilisation, pseudocereal proteins are definitely better when compared to cereals. The nutritive value of pseudocereals is very much competitive to conventional crop, in most cases even better.

2.2 Floristic Composition of India

India is the seventh largest and tenth industrialised country in the world with a geographical area of about 3287,263 sq km situated between 804′ N to 3796′ N latitude and 6807’ E to 97025′ E longitude. The Indian subcontinent is divided into four climatological zones – equatorial, tropical, subtropical and warm temperate according to longitudinal variation.

India represents about 11 % of the world's flora in spite of having only just about 2.4 % of the total landmass. India has two biodiversity hotspots, namely, Eastern Himalaya and Western Ghats, out of the 25 biodiversity hotspots (Fig. 2.1) identified in the world (Myers 1990). These two hotspots show most of the plant diversities in India. As far as species diversity is concerned, approximately 45,000 plant species are recorded in India (Khoshoo 1995; Sharma et al. 1997). In India the angiosperm flora is represented by approximately 17,500 species of which 5725 species belong to endemic category. In another estimation about 28 % of the total Indian flora and about 33 % of angiosperm flora occurring in India are endemic (Nayar 1996). In a rough estimate about 10 % of flowering plant species in India are threatened and 34 plant species have been declared to be extinct (Nayar and Sastry 1987–1990).

India is one of the versatile centres of diversity of cultivated plants. This region is characterised with enormous landrace diversity which is gifted with useful gene pools for tolerance to physiological and ecological stresses and resistance to disease, pest, etc. and good quality traits. Wild relatives and progenitors of cultivated plants are of particular importance. About 326 of such plants have been identified in India. Nearly 1000 wild plant species which are edible have been widely exploited by native tribal people (Arora and Nayar 1984; Arora 1985, 1987; Arora et al. 1991; Pandey 1998; Malik and Singh 2006).

All India Coordinated Research Project (AICRP) on underutilised crop (UUC) was initiated in 1982 with a headquarter at the National Bureau of Plant Genetic Resources (NBPGR),

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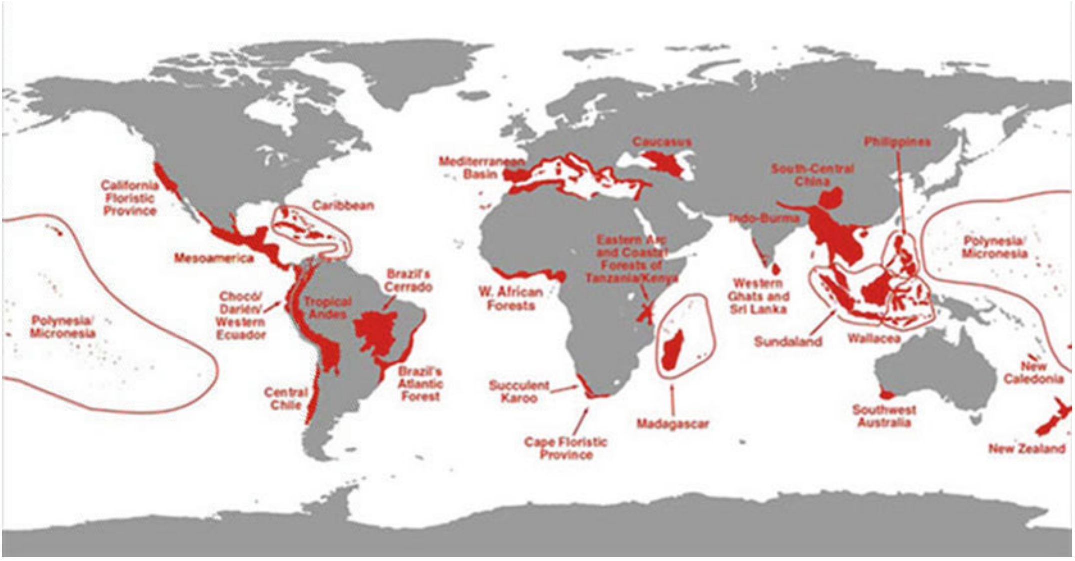

Fig. 2.1 Biodiversity hotspots identified worldwide with two biodiversity hotspot in India

New Delhi, with 15 main centres and 10 co-operating centres in different agricultural zones of the country.

AICRP has identified the following categories of underutilised crops which are to be considered for utilisation:

1. Pseudocereals – Grain amaranths, quinoa, buckwheat, Job's tear, etc.
2. Food legumes and pulses – Rice beans, winged beans, faba beans, etc.
3. Oilseed – Perilla, paradise tree, etc.
4. Vegetables – Kankora, winged bean, etc.
5. Fodder plant – Amaranth, salt bush, etc.
6. Energy, hydrocarbon and industrial plants – Jatropha, guayule, jojobe, etc.

The bulk of India's cereal supply (nearly 75 %) is provided by three major cereal crops like wheat, rice and maize, while minor cereals like *Avena sativa*, *Eleusine coracana*, *Echinochloa* sp., *Hordeum vulgare*, *Panicum miliaceum*, *Pennisetum* sp., *Secale cereale, Setaria italica* and *Sorghum bicolor* and pseudocereals like *Amaranthus*, *Chenopodium* and *Fagopyrum esculentum* provide only the remaining 25 %. More than 1200 cultivated and wild herbaceous plants are consumed as leafy vegetable. By the year 2020, the anticipated food grain demand would escalate up to nearly 250 million tonnes, which means an additional 72 million tonnes of food grains are to be procured.

2.3 Pseudocereals: An Alternative Food Resource

Cereals belong to the grass family (Poaceae) and cultivated for their starchy edible seeds. Pseudocereals are also grown for the same purpose, but they do not belong to the grass family. According to the definition proposed by Shewry (2002), pseudocereals are dicotyledonous species which are not closely related to each other or to the monocotyledonous true cereals. These are grouped artificially keeping in view the use only rather than the biology of plants and rapidly gaining popularity especially in the Third World countries. Cereals and pseudocereals are the primary suppliers of carbohydrates for the world's human population. The human population consume nearly half of the annual cereal production. The primary cereals comprise of rice, wheat, corn, sorghum, millet, oats, barley and triticale. The term millet refers to the small-seeded grain obtained from few unrelated species. Beside conventional cereals human food resources also include a wide variety of other plants like minor cereals and pseudocereals which are of minor significance not cultivated extensively but not at all negligible. Such plants have some obvious advantages: firstly they are adapted to drought and stress condition, secondly they have the ability to grow on poor soils of marginal areas unfit for other major crops and thirdly local rural people know well how to cultivate and use them. Such plants provide better nutrition than the major crops. The black fonio (*Digitaria iburua*) in Nigeria, white fonio (*Digitaria exilis*) in the rest of the tropical Africa, *Brachiaria deflexa* var. *sativa* and *B. ramose* in certain areas of Africa and the staple cereal Teff grass (*Eragrostis abyssinica*) in Ethiopia have gained great importance and popularity and contributed a lot towards food security specially in Africa. Few dicotyledonous members like *Amaranthus caudatus*, *Amaranthus cruentus* and *Amaranthus hypochondriacus* of Amaranthaceae, *Chenopodium quinoa* (quinoa) of Chenopodiaceae and *Fagopyrum esculentum* and *F. tartaricum* (buckwheat) of Polygonaceae produce starch-rich seeds that can be consumed as cereals, known as pseudocereals (Fig. 2.2).

2.4 Nutritive Value of Pseudocereals

The nutritive value of pseudocereals is much superior than cereals. As far as protein content and protein qualities are concerned, the pseudocereals are much better than the cereal species. Amino acids like tryptophan, lysine particularly lysine which is limiting in cereals is found to be present in high amount in pseudocereals. The amino acids arginine and histidine both proved essential for infant and child health present in significant amount in seeds, which projected amaranth and quinoa as an appropriate food supplement for child nutrition. Net protein utilisation (NPU) or protein efficiency ratio (PER), protein digestibility or bioavailability of protein and available lysine are some of the prime indicators of nutritional quality of a protein. From this view point, the values for pseudocereal proteins are definitely higher in comparison to cereals and are close to those of casein. The protein composition of pseudocereals is typical for dicotyledons in having 2S albumins, 11S and 7S globulins and therefore similar to protein of legumes, crucifers and composites (Marcone 1999). Due to lower prolamine content, the pseudocereal proteins are suitable for the person suffering from celiac disease. The fat content of pseudocereals is also higher compared to most cereal species and that fat is characterised with a high content of unsaturated fatty acids (e.g. linolenic acid). The mineral content in amaranth and quinoa is about twice as high as in other cereals.

The genus *Amaranthus* comprises many edible species besides many weedy members which grow worldwide but prefer the tropical climate. Amaranths are one of the earliest known crop plants extensively cultivated and utilised by the Aztec people, who considered it as a 'superfood'. Its exceptionally high nutritive value was explored long before. In Africa the leaves of the vegetable amaranths are consumed like spinach. The presence of amaranth seeds in the prehistoric period was evidenced through archaeological excavation at a cave in Tehuacan, Puebla, Mexico. The seeds of *Amaranthus cruentus* collected from Puebla, Mexico, dates back nearly 6000 years. Records from Aztec civilisation indicated the cultivation, collection and use of grain amaranths and also indicated collection of grains in huge quantities along with corn and beans as annual tribute to ruling elite class. The people of Aztec, Mayan and Inca civilisation (Fig. 2.3) used to grow different species of *Amaranthus* and consume both leafy vegetable and cereal grains. In Central America during the Mayan and Aztec period, people used amaranths as principal food. After the colonisation of America, the use of amaranths significantly faded out and its utilisation drastically decreased. This crop is now cultivated only in some pockets of the world as merely traditional regional crop, though global interest in amaranths has been rejuvenated in the last couple of decades.

Enzyme inhibitors and allergens are known to be present in cereals. Protein isolated from wheat,

Fig. 2.2 Different types of pseudocereals (**a**) quinoa, (**b**) buckwheat, (**c**) *Amaranthus*

Fig. 2.2 (continued)

Fig. 2.3 Use of grain amaranths in ancient civilisations

rice, maize and barley may cause allergic reaction, a gliadin fraction isolated from wheat causes celiac disease. But these components are not available in pseudocereals and legumes such as soybean and amaranths (Kuhn et al. 1996). Furthermore, pseudocereals contain dietary fibre in high proportion, which improves lipid metabolism (Gorinstein et al. 1998; Oleszek et al. 1999). The nutritional value of pseudocereals is mainly due to its protein fraction. Natural vegetable proteins of leafy amaranths are useful for its high biocompatibility, nutritional value and low cost. All the pseudocereals have major group of 11S globulin storage protein while smaller amounts of 2S albumin and 7-8S globulins are found in buckwheat and amaranths.

Pseudocereal quinoa (*Chenopodium quinoa*) is considered as the mother of all grains by the Incas and originated in the Andean region of South America. It is now produced in Bolivia, Peru and Ecuador. Unlike many other grains, it has a significant amount of protein and a well-balanced amino acid profile including high concentration of lysine (generally low in most other cereals). Its recognition as grain of high nutritive value has not been changed much since the Inca period, and today it is sometimes considered as 'supergrain'. It resembles amaranths in having a relatively high protein content of good nutritive value and great tolerance to arid condition (Taylor and Parker 2002). Possible utilisation of quinoa as food was studied by several researchers emphasising its use in the production of bread and cakes (Been and Fellers 1982; Lorenz and Coulter 1991; Chauhan et al. 1992) and pasta (Caperuto et al. 2001). Amaranths and quinoa both produce significant amount of edible grain, especially amaranth which is considered as the grain of the twenty-first century (Oleszek et al. 1999; Vetter 1994; Zheleznov et al. 1997; Gorinstein et al. 1996). Both amaranths and quinoa are very rich source of minerals and vitamins than most of the cereals (Vetter 1994; Gorinstein et al. 1996). Qualitatively and quantitatively the protein of grain amaranths is more superior than cereals and legumes (Singhal and Kulkarni 1988). The protein content of *Amaranthus* is about 16 %, and proteins are also enriched with high content of arginine, lysine, tryptophan and sulphur containing amino acids (Oleszek et al. 1999; Vetter 1994). The lysine content of amaranth is twice that of wheat and thrice that of maize, and the nutritive value is about 75 compared to 44, 57 and 62 for maize, wheat and barley, respectively (Zheleznov et al. 1997). It has also been observed that the globulin fraction of oat and amaranth is highly homogeneous and shares similarity with the legume 11S storage protein (Bressani and Garcia-Vela 1990; Segura-Nieto et al. 1994; Gorinstein et al. 1999). Main storage protein fractions, such as prolamins in cereals and globulins in pseudocereals were investigated by several workers (Konishi and Yoshimoto 1989; Ker et al. 1993; Gorinstein et al. 2002). A correlation between nutritive value of protein and amino acid composition revealed a close identity between soybean and amaranth. The suitability of amaranths as a nutritive substitute for cereals is well substantiated by its rich protein and amino acid composition.

Buckwheat, not a type of wheat but another pseudocereal, has also gained attention as a prospective crop. It also contains protein of high nutritional value and the protein is relatively rich in lysine and other essential amino acids. It is enriched with high amount of phenolics, iron, chromium, calcium, magnesium, selenium and polyunsaturated fatty acids. Buckwheat originated in the Middle Asia and was transported to Central and Eastern Europe by the nomadic people. Within the thirteenth century, buckwheat gained some importance in Germany, Austria and Italy, which was eventually lost due to the cultivation of other cereals. Today, due to the demand of gluten-free diet, the interest in buckwheat has been revived (Tables 2.1a and 2.1b).

According to the recent APG classification, both the genus *Amaranthus* and *Chenopodium*

Table 2.1a Percentage based dry weight of chemical components of amaranth, quinoa and buckwheat

Components	Amaranth (*Amaranthus cruentus* L.)	Quinoa (*Chenpodium quinoa* L.)	Buckwheat (*Fagopyrum esculentum*)	Wheat (*Triticum aestivum* L.)
Protein	15.2	13.3	10.9	11.7
Fat	8.0	7.5	2.7	2.0
Starch	67.3	69.0	67.2	61.0
Ash	3.2	2.6	1.59	1.8

Souci et al. (2000)

Table 2.1b Comparative account of nutritive value of grain amaranths and other cereals

Crops	Protein	Fat	Carbohydrate	Calcium	Iron	Phosphorus	Food energy
Amaranth	16.0	3.1	60.0	0.49	17.5	0.60	391
Rye	12.1	1.7	73.4	0.38	10.5	0.37	334
Buckwheat	11.7	2.4	72.9	0.12	15.5	0.28	335
Chenopod	12.0	5.0	68.0	0.20	12.6	0.50	342
Wheat	13.3	2.0	71.0	0.41	10.5	0.37	333
Maize	9.2	3.9	73.7	0.20	3.5	0.25	355
Rice	7.0	1.0	78.0	0.20	3.5	0.18	345

Souci et al. (2000)

are now included in the family Amaranthaceae under the order Caryophyllales, whereas buckwheat (*Fagopyrum* sp.) is included in the family Polygonaceae under the order Polygonales. Polygonales and Caryophyllales are closely linked, though Drzewiecki et al. (2003) found significant genetic divergence between Caryophyllales and Polygonales.

Amaranths: The Crop of Great Prospect

3

3.1 General

Amaranthus is a widely distributed herbaceous genus of herbs comprising approximately 70 species collectively called amaranths or pigweeds. Most of them are annual weeds; few are known as nutritive vegetable and graceful ornamentals, while protein-rich grains of few species are consumed as pseudocereals known as grain amaranths. The species number is still tentative due to misapplication of names and synonyms applied to the misidentified names. Three species of *Amaranthus* are familiar for grain production – *A. hypochondriacus*, *A. caudatus* and *A. cruentus*. According to one school of thought, all the grain amaranths are of the New World origin, but other school of thoughts suggested that grain amaranths might have been cultivated in South Asia from prehistoric period and probably have domesticated there. A comparative study of grain amaranths in India and Central America indicated close similarity in species distribution, evolution, variety pattern and cultivation practices. Seeds of grain amaranths are very rich in crude protein with lysine and threonine. Average protein score is either equal or much greater than rice, wheat, soybean and maize. Seed oil contains squalene, trypsin inhibitor, tocotrienols, tannins, etc. Vegetable amaranths are the most popular vegetable crops in tropics especially in the tropical humid climate of Africa and Asia. Several species are known as vegetable amaranths of which two are most popularly grown, *A. tricolor* and *A. blitum*. The tender plant of grain species *A. cruentus* is also consumed as leafy vegetable. Green amaranths are rich source of lysine-rich protein, β-carotene, various vitamins, minerals and dietary fibres. Anti-nutrients like nitrates and oxalates are present in small amount that does not cause any nutritional problem under normal condition of consumption. The underutilised amaranths are projected as crop of the twenty-first century because of their health benefits and nutritive value. Vegetable amaranths provide energy, help to maintain proper mineral balance, reduce bad cholesterol, improve eyesight and prevent anaemia. Compared to wheat, rye, rice and oat, grain amaranths are gluten free and contain 30 % more protein with complete set of amino acid. Amaranth grain may be processed in various forms like flaked, popped, extruded and ground into flour and also can be used as a substitute in porridge, stirred into soup. Grain amaranths have several health benefits like lowering of plasma cholesterol level, protection of heart, stimulation of immune system, anticancer activity, control of blood sugar level, improved condition of hypertension and anaemia, anti-allergic and antioxidant activity, etc., due to the presence of some bioactive components. Like other vegetables, green amaranths go through cooking such as frying, simmering, boiling, steaming and blanching before consumption. Cooking has a significant effect on bioactive components either positive or negative depending on the process. Amaranths are also known for its weedy members known as

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pigweed. Approximately ten *Amaranthus* species are regarded as weeds. They are also capable of competing with other crop plants, express highly flexible adaptability to environmental changes and various ecoclimates and ensure their existence producing a large number of seeds.

3.2 Grain Amaranths: A Nutritive Supplement to Major Cereals

Amaranthus L. is a cosmopolitan genus of herbs of the family Amaranthaceae collectively known as amaranths or pigweed. It includes about 70 species (Costea et al. 2001a, b; Iamonico 2012) and 40 of which are considered native to America. In another estimation the genus *Amaranthus* is reported to include 87 species, of which 14 found in Australia, 17 found in Europe and 56 available in America (Jacobsen and Mujica 2001; Mujica and Jacobsen 2003). Among the American species, ten are dioecious and the remaining 46 are monoecious. Dioecious species are confined in North America. Distribution of monoecious species in American subcontinent is scattered: 13 species are endemic to North America and Mexico; 17 species are restricted to Antilles, Central America and South America; and the remaining 16 species are quite common to Americas. It is very difficult to decide which are distinct species and which are synonyms applied to the misidentified specimen. Same new species of considerable phenotypic differences from the existing species may turn out to be ecotypes or natural hybrids of complete sterility or marginal fertility, but such plants may be included as new species (Chan 1996). There is no general agreement on the taxonomy of amaranths and species number. Brenner et al. (2000) and Robertson (1981) mentioned about 60 species, while USDA, ARS included 86 species under the genus *Amaranthus*. Behera et al. (1974) and Brenan and Townsend (1980) included 50 species under *Amaranthus*, while Sauer (1993) considered 75 species under the genus *Amaranthus*. Over 400 varieties are included within *Amaranthus* found throughout the tropical and temperate regions of the globe. Approximately 25 species of *Amaranthus* are available in Asian region. The antiquity of amaranths in Indian subcontinents was evidenced by fossil record of *Amaranthus* pollen documented in several excavations in India that dates back to the Holocene and late Palaeocene periods.

The species of *Amaranthus* are mostly annual weeds; few are utilised as vegetables and ornamentals. Protein-rich grains or seeds of few species (*A. caudatus* L., *Amaranthus hypochondriacus* L. and *A. cruentus* L.) are consumed as pseudocereals; they are called grain amaranths. All the species fall roughly under any of the four categories – grain, vegetable, ornamental and weed. Amaranth is considered as one of the few multipurpose crops which supply seeds in huge quantities that can be used as pseudocereals, as tasty leafy vegetable of higher nutritional quality and also as food and animal feed. Some member has attractive inflorescence of various colours that made them valued as ornamental also. Although the crop was one of the sources of staple food in the pre-colonised South American civilisation, the cultivation and knowledge fell into oblivion, and thus nowadays it could be considered as a new, forgotten, neglected but prospective and alternative crop of immense nutritive potential. The grain amaranths growing in the Himalayan region show wide genetic diversity and morphological variability, which surely substantiate the speculation about probable spread of the crop in India from that region in the eighth century. Based on direct and indirect evidences regarding antiquity of the crop in India, Joshi and Rana (1991) suggested that the grain amaranths were prevalent in South Asia from the time immemorial (Joshi and Rana 1991). In Asia one can find a great ill-defined grain amaranth region extending all the way from Manchuria through interior China and Himalaya to Afghanistan and Persia. Wide scattering of the crop throughout Asia and popularity and traditional use of the grains in marginal areas are supportive to its antiquity in the area.

The word 'amaranth' originated from the Greek word 'amarantos' which means 'unwithering'. The term was applied to amaranth to signify its hearty characteristics symbolising immortality. Grain amaranths are grown all over India from