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FOREWORD

Humankind has been using plants for food, fodder, fiber, medicine and other economic purposes since the dawn of agriculture and is likely to do so in future. Useful plants occur at various stages of domestication and require different degrees of management. Underutilized plants, at preliminary stages of domestication, provide household food and nutritional security to millions of impoverished people inhabiting remote and inhospitable areas. The genetic make up such plants imparts tolerance to stresses and are important source of nutritional / industrial value for a variety of purposes. In some cases the undesirable traits like presence of anti-nutritional factors, shattering/lodging habit and low yields prevail upon and restrict their adoption at a larger scale. For such species human intervention is required for their improvement and find out suitable niches for their adoption before they are put under large scale cultivation. About 70 species have been identified as important underutilized and neglected crops/plant species in Asia-Pacific region which have potential to be exploited for commercialization. Some of these under utilized food crops such as amaranth and buckwheat are highly nutritious. They possess quality proteins with high amount of limiting amino acids such as lysine and methionine which are low in other major cereals like wheat, rice and maize.

Realizing the significance of the under utilized and under explored plants in diversifying agriculture under different strategic situations, an All India Coordinated Research Project (AICRP) on Underutilized and Underexploited Plants, now rechristened as All India Coordinated Research Network on Underutilized Crops, was initiated in 1982 under ICAR umbrella with the main objective of generating improved technology in selected crops of the minor economic importance for food, fodder and industrial use. During the last twenty six years under this project, research work has been carried out on about seventeen plant species in the direction of collection of plant materials, their improvement and generating package of practices for their cultivation. Thirty three improved varieties in different crops for various agro climatic zones have been released and their cultivation practices standardized. It is important to summarize the achievements of the project in terms of the varieties released and improved cultivation

practices generated for the benefits of farmers. Therefore, a need was felt to bring out a publication having compiled information on the uses, varieties released and package of practices standardized for cultivation of these crops. I appreciate the efforts made by authors for bringing out this publication "Underutilized Crops: Improved Varieties and Cultivation Practices" and hope that this will be very useful to planners, researchers, students and farmers.

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INTRODUCTION 1

Ever since the dawn of civilization, dependence of human kind on plants has been indispensable for survival. Transformation from food gathering to settled agriculture necessitated domestication of plant species useful for mankind leading to co-evolution of plants and man in absolute harmony with nature. Out of an estimated total of 80,000 plants of possible economic use about 30,000 plants have been found to be edible in nature and approximately 7,000 plants have been cultivated by mankind at one time or the other, of which only 158 plants are widely used for food (Wilson, 1992). Among these food plants 30 crops provide 90% of the world's food and only 10 crops supply 75% of the world's food budget. Out of the above only three crops, rice, wheat and maize provide 60% of the world's total food requirement (Harlan 1992). This narrow level of food base may imperil the existence of mankind during the time of impending crisis in unforeseen times to come. Therefore, there is a need to enlarge our food basket with alternative food crops to safeguard against such a catastrophe. Consequently, in recent years, there has been a global concern to collect, introduce, evaluate and utilize the vast array of lesser known, under-exploited, alternative crop plants to diversify the agricultural system. Also, it is estimated that 82 per cent of total land area in South Asia suffers from one or the other kind of stress (drought - 43%, mineral stress - 5%,

Table 1. Nutritional status of minor food crops per 100 g (Joshi and Paroda, 1991)

Food grain	Protein (g)	Carbohydrates (g)	Lipid (g)	Crude fibre (g)	Mineral matter (g)	Calcium (mg)	P (mg)	Fe (mg)
Amaranth	**16.0**	62.0	8.0	2.43	**3.0**	**490**	**600**	**17.5**
Buckwheat	13.0	72.9	7.4	**10.5**	2.1	**120**	280	**15.5**
Chenopodium	14.0	65.0	7.0	-	**3.0**	-	-	-
Job's tear	11.4	73.5	3.5	-	0.8	-	-	-
Foxtail millet	12.3	60.9	4.3	**8.0**	**3.3**	31	290	5.0
Maize	11.0	66.0	3.5	-	1.1	-	-	-
Barley	11.0	69.0	1.3	-	1.9	-	-	-
Wheat	12.0	69.0	1.7	1.2	2.7	41	306	5.3
Rice	6.7	78.0	0.3	0.2	0.3	45	160	3.5

shallow soil depth 23% and excess water - 11%) and only 18 per cent area is free from any serious limitation (Dent, 1980). Decreasing availability of land for agriculture, due to diversion of land for industrial use, urbanization, etc. has led to more dependence on degraded lands to meet the increasing requirements of food, fodder, fiber, firewood and timber during the 21st century. The, underutilized crops, which are adapted to stressed environments and provide food and nutritional cover to about 10 per cent population inhabiting remote, tribal and backward areas, possess enumerable unique traits of nutrition (Tables 1, 2) and resistance to biotic and abiotic stresses and thus offer a good scope for diversification of agriculture. The implementation on World Trade Organization (WTO) regime and issues related to intellectual Property Rights (IPR) has also made it mandatory to search for novel genes and products from plant resources to retain competitive advantage at the global market.

About 70 species of underutilized, neglected and minor crops (Annexure 1) have been identified to have promise in the Asia pacific region (Eyzaguirre et al., 1999; Arora, 2002). Amongst this vast array of plants deserving attention, only a few have been prioritized for scientific exploitation in a phased manner based on their economic potential and niche advantage in India. For this All India Coordinated Research Projects on Underutilized and Underexploited Plants was initiated by the Indian Council of Agricultural Research in 1982 to provide necessary thrust for collection, conservation, evaluation and utilization of such neglected and underutilized crops. Further, value addition to these crops is a prerequisite to popularize and exploit them commercially among the elite strata of people.

Table 2. Essential amino acid composition (g/100g protein) in minor crops in caparison to cereals and milk (Bhagmal 1994)

Food grain	Lysine	Methionine	Cystine	Isoleucine	Leucine
Amaranth	5.0	4.0	4.0	3.0	4.7
Buckwheat	6.2	1.6	1.6	3.7	6.2
Foxtail millet	2.2	2.8	1.6	7.6	16.7
Proso millet	3.0	2.6	1.0	8.1	12.2
Wheat	2.8	1.5	2.2	3.3	6.7
Rice	3.8	2.3	1.4	3.8	3.2
Maize	2.9	3.4	3.4	4.1	13.0
Barley	3.0	3.2	3.7	4.0	7.5
Milk	5.8	3.7	2.1	5.0	7.3

Over the years, a sizable germplasm collection (over 13,000 accessions) was built up for evaluation. This provided the base material for development of about 33 improved varieties in different crops. Studies were carried out to find out suitable inter crops and management practices for cultivation of these crops in conventional and non conventional areas across different zones. In the present publication "Underutilized Crops : Improved Varieties and Cultivation Practices" an effort has been made to highlight the uses of different mandated crops of the project, improved varieties released for various agro ecological situations, the package of practices available for cultivation and the institutions which have developed the improved varieties and are multiplying the seeds for distribution to farmers and other agencies.

The text of this manual encompasses the work undertaken in All India Coordinated Project on Underutilized crops. However, some information regarding the uses and distribution etc. has been gathered from other publications also. The crops have been categorized in six groups namely pseudo cereals, minor cereal, food legumes, vegetables, oil seed crops and industrial crops. The list of other underutilized / neglected crops of Asia –Pacific region and the improved varieties developed in AICRP (Under utilized Crops) have also been annexed for the benefit of students and researchers.

PSEUDOCEREALS 2

The food grains comprising grain amaranth, buckwheat and chenopods belonging to three different families, Amaranthaceae, Polygonaceae and Chenopodiaceae, respectively are referred as pseudo cereals as they are distinguished from other true cereals which belong to family Poaceae

2.1 GRAIN AMARANTH (*Amaranthus sp.*)

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 grains. The tiny seeds of grain amaranths compare favorably with maize and other true cereals in nutritional value and yield (Sauer, 1967). Amaranth has very high nutritional value (Saunders and Becker, 1983; Joshi and Rana, 1991) 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 hemoglobin 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 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.

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 luster and are rich in proteins and minerals. The leaves are also rich in protein and are extremely useful from human nutrition viewpoint. 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 flowers are pentamerous and circumscissile utricles. The male flower has five stamens and the female, a single circumscissile utricle. The basic units of inflorescence are little dichasial

cymes called glomerules, which are crowded on a leafless axis to form complex inflorescence generally called spike. Each glomerule consists of an initial staminate flower with an indefinite number of female flowers. In grain types the percentage of male flowers is less than vegetable types. This promotes out crossing relatively to a large extent in grain types. Each flower is subtended by a sharp-pointed bract. Most of the species have 2n = 32 or 34 except polyploid species *Amaranthus dubius* which has 2n = 64 (WOI, 1985). Among various species, A*maranthus hypochondriacus* (L.), *A. cruentus, A. caudatus* and *A. edulis* are the main grain species, while *A. dubius, A. bilitum, A. viridis* and *A. tricolor* are largely grown for vegetable purpose. *A. hybridus* is a dual purpose specie used both for vegetable and fodder production. *A. spinosus*, a wild species, is an important source of genes for several useful traits.

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 (Sauer, 1967). In Asia-Pacific region covering India, China, Manchuria, Nepal, Bhutan, Afganistan, 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 the statistics on area and production in India is lacking. However, as a grain crop it is estimated to be grown in about 40-50 thousands 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 tones grains annually.

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 (Joshi and Rana, 1991). 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 (Sanchez-

Marroquin, 1983). 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 (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 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): T**he variety was developed at G.B.Pant University of Agril. & Tech. Hill Campus, Ranichauri, Tehri Garwal and was released in 1997 for Uttranchal 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 Agril.& Tech., Hill Campus, Ranichauri, Tehri Garwal from the local material of Saonli (Tehri). The variety was released in 2000 for North- West Himalayan region except J&K. 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 content (12%) 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 Agril.& Tech., Hill Campus, Ranichauri, Tehri Garwal and released in 2003 for North-West Himalayan region except J & K. It is recommended for timely shown , 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 Uttranchal. 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 with mosaic of yellow and red colour. Foliage turn 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 yellow in 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 Maharastra, Tamil Nadu and Gujarat states) of the country, the variety was developed at UAS, Bengalore 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 through out 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. The anthesis occurs during early hrs 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 in 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 colored 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 & 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 Agril. University, Mandor, Jodhpur as a selection from IC 35647 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 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 an height of about 1 m with about 50 cm long inflorescence. The creamy white seeds have 7.75 g weight of 10 ml volume.

Cultivation Practices

- 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.

- Two to three ploughings are enough for field preparation. With proper soil moisture in the field, the seeds should be shown about 2 cm deep in rows 45 cm apart with 10-15 cm distance between plants. Seed rate of 1.5- 2.0 kg/ha is enough for getting

good yields. In case water is not available for irrigation in time or rains are delayed then dry sowing can also be done. The seed will germinate when irrigation is given or rains occur. After one to two weeks of germination, thinning can be done to maintain the plant population at desired spacing.

- 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.

- To keep the field free from weeds, two hand weedings, first at 25 DAS and another at 50 DAS are recommended to get better yields.

- In hills, the crop is grown as rain fed. However, in plains the optimal irrigation schedule has been worked out to be about 0.6 IW/CPE and thus 4-5 irrigations are required for a good crop stand during rabi season.

- In hills, the crop can be suitably grown as a mixed crop with either maize, small millets, french bean or other beans. The best economic yields can be obtained when amaranth and french bean are grown in 1:2 row ratio.

- In Gujarat, the sole crop can be profitably grown in rabi season after taking cluster bean or sesamum in *kharif* season.

- In South India, inter cropping grain amaranth with pigeonpea has been found to be most profitable. Best results have been recorded when one row of amaranth is planted between two rows of pigeonpea spaced at 75 cm in Tamil Nadu and Orissa and two rows of amaranth are planted between two widely spaced (105 cm) rows of pigeonpea in Karnataka.

Researchable issues

1. High degree of seed shattering and lodging occurs at maturity. This makes the crop less productive. Therefore, the varieties resistant to lodging and shattering are required to be developed.

2. There is a major problem in grinding amaranth grains in normal grinders. This restricts its full utilization as a food crop. Therefore, there is a need to develop bold seeded varieties.

2.2 BUCKWHEAT (*Fagopyrum sp.*)

Buckwheat, though used as a cereal but does not have any relationship with common wheat. It is classified as pseudocereal and belongs to genus Fagopyrum of the family Polygonaceae, whereas common wheat, a true cereal belongs to family Graminae

/ Poaceae. There are two cultivated species of buckwheat, namely *Fagopyrum esculentum* Moench called as common or Japanese buckwheat and *F. tataricum* Gaertn. known as tatary buckwheat. The common buckwheat (*F. esculentum*), locally called as Ogla or Uggal, is a herbaceous annual erect plant with hollow stem having swollen nodes and alternate triangular leaves. The inflorescence is axillary and terminal cyme with densely clustered dimorphic flowers of white, pink or red colour. The species is cross pollinated and self-sterile. The fruit is a dry, single seeded, three-sided nut called achene, measuring about 6 mm x 3 mm. The colour of the seed is brown, grey-brown or black, marked with darker spots and lines. Tatary buckwheat (*F. tataricum),* locally called as Phaphra, is also herbaceous annual plant but taller and coarser with short internodes and narrow arrow shaped leaves. All the flowers are similar and borne on axillary recemes with inconspicuous light green sepals. This species is self-fertile. The wild species, *F. cymosum* Meisnn, is a tall vigorous growing perennial with large, long stalked triangular leaves. All the three species are diploid with chromosome number 2n = 16.

Distribution and Adaptation

The centre of origin of buckwheat is believed to be Himalayan region either in Western China or Northern India (Elagin, 1959). However, according to Tsvetoukhine (1952), the centre of origin of buckwheat is Manchuria. The biology of the plant, its present distribution and linguistic evidences conclude that *F. esculentum* originated in the Himalayan region and was introduced into Southern Russia in the first century A.D. (Elagin, 1959). The wild species *F. cymosum* is believed to be the progenitor of the two cultivated species (Krotov, 1963).

The range of distribution of buckwheat in mountainous regions extends from Pakistan to India, Nepal, Bhutan and Myanmar. It is also grown in China, Japan, Korea, Iran and Afghanistan. In India, the crop is grown from Jammu and Kashmir in the west to Arunachal Pradesh in the east. In hills of Chhatisgarh also, people of Tibbetan origin

cultivate this crop. The exact area under this crop is not known. However, rough estimates indicate that about 20-25 thousands ha area is covered by this crop.

Uses

- Buckwheat is a multipurpose crop. It is an important food grain for the people in hills of certain regions in India, Bhutan and Nepal.
- The whole plant, young shoots, leaves, flowers and grains are used in variety of ways. The tender shoots are used as leafy vegetables. The grain is used in several culinary preparations during fast and religious festivals in India.
- Its starchy flour can be used as sweet puddings for making *chillare*, an unleavened bread fried with wheat and barley flour for making *chapattis*. Husked kernels are cooked as rice.
- In Uttaranchal, country liquors called *pechuwi* and *chhang* are made from buckwheat (Joshi and Paroda, 1991). Common buckwheat flowers are rich source of dark coloured and strong flavoured honey.
- The plant has a medicinal value due to presence of a glucoside called 'rutin' which strengthens blood vessels and is used in the treatment of several other diseases also.
- Buckwheat grains are used as livestock and poultry feed. The crop is suitable for fodder, green manure and is a good soil binder.
- Buckwheat is an excellent source of lysine and is the only food grain, not deficient in nutritional quality (Lyman *et al.*, 1956). Buckwheat grain contains comparatively lesser protein than that of wheat, barley, rye or oats but slightly more than that of maize. The biological value of protein is superior to other food plants and is nearly equal to that of eggs.

Varieties

1. **Himpriya :** It was developed at NBPGR Regional Station Shimla as a pure line selection from IC 13374 , the material collected from Kinnaur district of Himachal Pradesh. This is the first improved tataricum variety released in 1991 for high altitude areas of Himalaya including North Eastern Hill Region. On an average, it gives grain yield of 12 q/ha. Its plants attain an average height of 1.3 m. It takes, on an average, 64 days for 50% flowering and 119 days for maturity. Seeds are brownish and have conical shape. The variety is free from leaf spot diseases and insects/pests including storage pests. It is suitable for early as well as normal planting. It has very good fodder plant type and improves soil texture when used as green manure. Being early in maturity, it can suitably be taken in crop rotation with peas or barley in higher hills.
2. **VL UGAL 7 :** The variety released in 1991, was developed at Vivekanand Parvatiiya

Krishi Anusandhan Sansthan through mass selection from USDA material (USDA -1), originally collected from areas of Kukumesri Research Station of HPKVV, Palampur. It is a high yielding variety of common buckwheat (*Fagopyrum esculentum*) and is most suitable for cultivation in mid hills and valley areas. The variety is identified for the mid hill regions of Uttar Pradesh (Now Uttarakhand). Under normal kharif planting, its plant height ranges between 110 and 130 cm. Stem is hollow, turning red at later stages after sun-burning. Inflorescence is axilary with white clustered flowers. It has black bold seeds (2.3 g/100seeds) with three winged sides and is extra early in maturity taking about 70 days in spring planting and 55-60 days in normal or late kharif sowings in valleys and thus helps in enhancing the cropping intensity. Though it gives seed yield of about 8.0 q/ha but its per day productivity comes to be higher than other varieties on account of its early maturity.

3. **PRB 1 (PRB 9001) :** Variety released in 1997 for hill regions of Uttar Pradesh, Himachal Pradesh and North Eastern States, was developed at G.B. Pant University of Agril.& Tech., Hill Campus, Ranichauri, Tehri Garwal through a selection from local material of Ranichauri. The variety belongs to *esculentum* group and matures in about 102 days taking 10-15 days less than Himpriya. Thus, the variety suits well to double cropping system in mid and high hill regions. It requires low inputs under timely and late sown conditions. The variety has slightly bolder seeds (2.3 g/100seeds) than Himpriya and is high yielding giving an average grain yield of 12 q/ha. Its growth habit is tall, erect and highly branched having about 12 branches/ plant. Average plant height is 131 cm and has dark green foliage.

4. **Himgiri (Shimla B1) :** The variety belongs to species *Fagopyrum tataricum* and is identified as early maturing with high yield. The variety developed at NBPGR Regional Station Shimla through pure line selection from EC 321798, was released in 2005 for mid and high hills of Himachal Pradesh and Uttaranchal. The variety can fit well in double cropping system where buckwheat is grown after potato, cabbage, pea and hops during mid August to mid October. The variety gives an average grain yield of 11.12 q /ha and matures in 86 days as against Himpriya which matures in 124 days. The seed colour of this variety is brown as against other varieties which have black seeds. Stem is green and stout with smaller leaves. Peduncle and cyme are longer than 'Himpriya'.

5. **SANGLA B1:** The variety released in 2005, for mid and high hills of Himachal Pradesh and Uttaranchal, was developed at Mountain Research and Extension Centre, Sangla (CSK HPKV Palampur) as a pure line selection from the indigenous material collected from dry temperate region of Himachal Pradesh. This tataricum variety is medium in maturity (106 days) and gives an average grain yield of 13 q/ ha. The variety matures earlier than Himpriya and escapes frost. It is resistant to powdery mildew. It has determinate and bushy growth habit. It attains a height of about 120 cm. It has small light greenish flowers. Stem colour is pinkish green with dark green leaves. The raceme is axillary. The seeds are conical and brownish grey in colour with 2.1g test wt.

Promising genotypes and land races

1. **1C 258233 :** Registered at NBPGR, New Delhi for easy dehulling in *Fagopyrum esculentum* by NBPGR, Regional Station , Shimla
2. **OC 2 :** Local material suitable for Himachal Pradesh and Uttranchal
3. **Kamroo local :** Local material suitable for Himachal Pradesh and Uttranchal

Cultivation Practices

- Buckwheat thrives best on a well drained sandy loam soils under cool and moist conditions. One or two discings followed by planking is desired for good pulverization of the soil.
- Sowing period varies from region to region, the best period being May-June in North-Western hills, August in North-Eastern hills, April in Nilgiri hills and January in Palni hills.
- Optimum seed rate is 35-40 kg/ha. The sowing should be done at 4-6 cm depth in rows 30 cm apart. Thinning could be done at 15-20 days after sowing to maintain plant to plant distance at 10 cm.
- Application of fertilizer dose of N:P:K @ 40:20:20 kg/ha is recommended. However, the crop also responds to higher dose of N (60 kg/ha). If required, lime can be added in acid soils.
- To keep the field free from weeds, one hand hoeing at 20-35 DAS is desirable. For chemical weed control, pre-emergent application of alachlor @ 1.5 kg a.i. /ha is recommended.
- In order to increase the seed set in common buckwheat, apiary be encouraged in hills. This will give an additional income also by getting 60-70 kg of honey per hectare.
- In tatary buckwheat, clipping at 60 DAS has been reported to increase seed yield by 3-4 q/ha.

Researchable Issues

1. Indeterminate growth habit, susceptibility to lodging, seed shattering, high percentage of flower drop and low seed setting are the main limitations in buckwheat cultivation. Therefore, selection of desired plant types is required
2. *F. esculentum* is self incompatible and if rains occur during flowering, enough pollen is washed and yields are poor. So, there is a need to search for self compatible types.

3. To exploit its nutritive value, there is a need to undertake studies on value addition in its processed food products.

4. Research is required to establish the role of its 'Rutin' and other contents for their medicinal value.

2.3 GRAIN CHENOPODS (*Chenopodium* sp.)

Chenopods, the ancient food crops, belong to genus *Chenopodium* of family Chenopodiaceae. Four species, viz. *C . album, C. quinoa, C. nuttaliae* and *C. pallidicaule* are known to be cultivated. Among them, *C. album* (L), a diploid specie (2n=18) is commonly grown in the Himalayan region and is locally called bathu or bathwa. Its one form cultivated as leafy vegetable is referred as chandan bathwa. The other tall robust form, cultivated for grains in North-Western hills, earlier regarded as *C. giganticum* is now recognized as a variety of *C. album* L. Steward. The three other species, originated in South America, are closely related and are referred as American grain Chenopods. Among them, the most important Andean chenopod is *C. quinoa* and 'Incas' regarded it as a sacred plant. *C. nuttaliae*, locally called 'huauzontle' is grown for seeds and *C. pallidicaule*, known as 'canahua' is adapted to the high elevations due to its short growing season. Quinoa (*C. quinoa* Willd.) is a gynomonoecious annual plant with an erect stem and bears large sized alternate leaves (Bhargava et al. 2006a). The plant exhibits high level of resistance to several predominant adverse factors like soil salinity, drought, frost, diseases and pests (Bhargava et al. 2003a). These benefits necessitated introduction of quinoa to newer areas outside its native region.

Uses

Chenopods have multiple uses. Different species are grown and used for specific purposes. Its green leaves are comparable to any leaf vegetable as it is rich in iron, beta

carotene and low in oxalate content.

- The grain chenopod is more nutritive than the cereals and is equivalent to whole dried milk (Philip, 1955). Chenopods contain exceptionally high lysine comparable with animal food sources and have higher amount of methionine and cystine. The grains are sometimes used as staple food and consumed in the form of porridge, pudding, gruel and cooked with rice. It is considered as a sacred food and used on days of religious fast. Its flour blended with that of wheat, maize and buckwheat is used to make bread (Chapatis).
- It is also used in the preparation of a local fermented beverage called 'soor' and locally distilled alcoholic drink 'Thara' or 'Chanti' (Pratap, 1990).
- The whole grain is also used as poultry and livestock feed. The whole plant can be used as fodder.
- The leaves and young shoots are used as vegetable oftenly mixed with other leafy vegetables and most commonly used in preparation of 'raita' mixing it with curd.
- Dried stems are used as fuel.
- It is also used as a pot herb.
- The plant also contains etherel oil, a substance resembling cholesterol, ammonia and amines, in both free and combined forms (WOI, 1985).

Distribution and Adaptation

Grain chenopods are cultivated in high hills and valleys between 1500 – 3000 m elevation in isolated areas of North-West and East Himalayas. These are successfully cultivated in climates with average temperatures ranging from 5°C to 30°C and average annual rainfall of 40 – 120 cm. It tolerates frost which is common during crop growth period. It is also adapted to wide range of soil types, particularly those with poor fertility and on high altitudes unsuitable for wheat and barley cultivation. In Northern plains, it grows wild during winter. The information on area, production and productivity of grain chenopods is meager. According to a conservative estimate, grain chenopods are cultivated in nearly 1500 ha in mixed farming systems with a production of about 4000 quintals, half of which is diverted to local and regional markets (Pratap, 1990). The average yield is reported to be between 2.6 and 4.3 q/ha. However, the potential of some of the genotypes in All India Coordinated trials has been recoded to be 10 q/ha under favourable conditions.

Promising genotypes

There is no released variety in Chenopodium for grain purpose. However, selections made from the collections of different regions and evaluated in All India Coordinated Research Network on Underutilized Crops over the locations and years have led to identify some good genotypes.

1. **SMLCP 2 :** The selection from indigenous collection 'IC 329521' of *Chenopodium album* has been developed at NBPGR Regional Station Shimla. Leaf size is medium, hestate with obtuse tip. Seedling vigor is very good. Stem is green, turns red on maturity and is generally unbranched erect. Plant attains height of about 2 m. Inflorescence is medium long, compact type, green and has more panicles. On an average, it flowers in 70 days and matures in about 135 days. The seeds are black and medium in size (1.1g/1000 seeds). There is no report of any disease incidence in this genotype. However, if there is heavy rain fall at germination, most of the seedlings die due to damping off. But once the plant attains a height of 6", it grows very well and out competes the weeds. The seeds remain viable even after 5 years when stored at room temperature. The average seed yield over the locations and years has been recorded to be 8.6 q/ha.

2. **SMLCP 5 :** Selected at NBPGR, Regional Station shimla. The average seed yield has been recorded to be 6.0 q/ha in AICRP trials.

3. **PRC 9801 :** Selected at GBPAUAT, Ranichauri. The average seed yield has been recorded to be 5.75 q/ha in AICRP trials

4. **EC 507751** : Average seed yield has been recorded to be 7.22 q/ha in AICRP trials

5. **NIC 22503 :** Average seed yield has been recorded to be 7.75 q/ha in AICRP trials

6. **IC 258253 :** Registered for brown seeded chenopod by NBPGR, Regional Station, Shimla

Cultivation Practices

- In hills, grain chenopods are usually grown in summer under marginal farming conditions, mostly in crop mixtures and rarely as mono crop. In North - West Himalayas it is grown in mixture either with one crop such as finger millet, potato, maize, upland rice or with two crops such as finger millet + amaranth or finger millet + fox tail millet or upland rice + sesame or with three crops such as Maize + amaranth + cow pea or finger millet + fox tail millet + black gram (Bhagmal, 1994).

- The crop is sown in April at higher elevations and in May – June in the valleys. In upper Kullu valley seed is sown during July – August. In mixed cropping systems, seeds are generally sown by broadcasting after the main crop has been sown in rows. For mono cropping, the seeds are sown in rows spaced 50 – 75 cm apart.

- A seed rate of 2 kg/ha for broadcasting and 1 kg/ha for line sowing is adequate. The seeds are mixed by raking with thorny bushes or by harrow

- Thinning is done to have optimum plant population.

- The crop does not need much after-care. At maturity, the plants are cut, put in bundles, dried, threshed and winnowed.

Limitations and Researchable Issues

1. There is a need to develop early, bold and high yielding varieties with tolerance to lodging, frost, shattering and bird damage.
2. There is a need to develop saponin free high yielding varieties for better taste and digestibility.
3. It is desired to develop varieties for dual purpose i.e. grain and vegetable.

MINOR CEREAL 3

The group comprised only one crop belonging to cereal group. Because of its limited cultivation on a very small scale and used in small pockets, this has been categorized as a minor cereal.

3.1 JOB'S TEAR (*Coix lacryma – jobi* L.)

Job's tear or adlay (*Coix lacryma – jobi* (L)) is commonly known as Jargadi in Sanskrit, Sankru in Hindi, Gurgur in Bengali, Netpavalam in Tamil, Ranmakha in Marathi and Sohriu in Khasi Hills. It is a tall (3–6 ft in height), erect, diploid (2n=20) annual plant with broad leaves. This minor cereal belongs to family Gramineae / Poaceae. The plant is monoecious with terminal loose spike which bears large, shining, pear shaped fruits showing fanciful resemblance to tears. The fruits contain a whitish or light brownish grain similar to rice.

Uses

- Job's tear is considered to be a good substitute for rice. Rather, it is considered to be more wholesome by virtue of its higher fat and protein content.

- It can be used in preparation of any food item that is usually made from rice with same degree of palatability.
- Milling and baking trials in Philippines showed that its flour is suitable for baking purposes when mixed with wheat.
- A light beer 'Dzu' is made from adlay by the Nagas.
- The fruits are used in medicine either as tincture or as decoction for catarrhal infection of the air passage and inflammation of the urinary passage.
- The fruits of wild varieties, var. *stenocarpa* and var. m*omilifera* are used for making necklaces, rosaries, bead curtains etc.
- The foliage may be used as fodder for cattle, horses and elephants. It can also be turned into silage.
- The mature straw and leaves are used for thatches.

Distribution and Adaptation

Job's tear is a native of South-East Asia. It is distributed through out the tropical and subtropical parts of the world and its cultivation is reported in Philippines, India, China, Siam, Myanmar and Sri Lanka. In India, this plant is found in warm slopes of hills up to an elevation of 1600 m particularly in North Eastern states.

Promising genotypes and land races

There is no released variety in Job's tear for grain purpose. However, the selections from collections of different regions evaluated in All India Coordinated Research Network on Underutilized Crops over the locations and years led to identify some of the good genotypes. These are:

H 2287 : Selection made at NBPGR, Regional Station Shillong, Meghalaya. Average seed yield of 7.5 q/ha has been recorded in AICRP trials.

IC 012703 : Selection made at NBPGR, Regional Station Shillong, Meghalaya. Average seed yield of 7.24 q/ha has been recorded in AICRP trials.

IC 089389 : Selection made at NBPGR, Regional Station Shillong, Meghalaya. Average seed yield of 6.4 q/ha has been recorded in AICRP trials.

H0732 : Selection made at NBPGR, Regional Station Shillong, Meghalaya. Average seed yield of 6.4 q/ha has been recorded in AICRP trials.

IC 089385 : Selection made at NBPGR, Regional Station Shillong, Meghalaya. Average seed yield of 6.2 q/ha has been recorded in AICRP trials.

Mayeun Local : Local material recorded an average seed yield of 6.7.q/ha in AICRP trials.

Pollin Local : Local material recorded an average seed yield of 6.1 q/ha in AICRP trials.

Cultivation Practices

- Job's tear grows on well drained high lands. Sufficient rains in early stage of growth and a dry period at the time of grain setting are necessary for getting good yields.
- It is sown with the onset of monsoon using a seed rate of 6 - 10 kg/ha.
- The crop has been reported to respond fairly to application of organic manures. However, a fertilizer dose of N:P:K @ 40:20:20 kg/ha is recommended to get good yields. The seeds can be sown in rows, 45 cm apart, keeping plant to plant distance of 15 cm.
- The crop is harvested 4 - 5 months after sowing.

FOOD LEGUMES 4

Legumes have a special significance in agriculture as they provide a sustaining source to other crops in the system through soil enrichment by symbiotic nitrogen fixation. They also add value to human diets by providing high protein food. Besides major pulses such as chickpea, pigeonpea, green gram, black gram, lentil and peas there are other several legumes which are cultivated for multifarious uses in marginal lands mainly in remote areas and have tremendous scope to become important component of agricultural system because of their being intrinsic resilient and associated with important useful traits. The important ones include rice bean, faba bean, adzuki bean and winged bean. Many of them are nutritionally better as compared to major pulses.

Table 3.Nutritive value (per 100g) of underutilized and major food legumes (Bhagmal, 1994)

Crop	Crude protein (g)	Fat (g)	Carbohydrate (g)	Fiber (g)	Ash (g)
Rice bean	20.9	0.9	60.7	4.8	4.2
Faba bean	26.2	1.3	59.4	6.8	3
Adzukibean	19.9	0.6	64.4	7.8	4.3
Winged bean	32.8	17.0	36.5	4.1	3.6
Chick pea	19.4	5.6	60.9	2.5	3.1
Pigen pea	21.6	1.4	72.7	8.1	4.2

4.1 RICE BEAN (*Vigna umbellata* (Thunb.) Ohwi and Ohashi)

Rice bean, also known as Climbing bean, Mountain bean, Mambi bean, Oriental bean, Haricot bean, Red bean and Jerusalem pea, is a highly branched annual with erect or semi -erect stem tending to be viny. In India, it is known by different vernacular names such as moth, rajmoong and satrangi mash. It has axillary raceme inflorescence with bright yellow flowers occurring in clusters. Pods are slender and somewhat curved. Seeds are oblong with varying seed coat as smooth, dark wine, green, yellow,

brown, black, speckled or mottled. Wild forms are perennial, very viny, thin stemmed with tuberous root system. Five distinct botanical varieties of rice bean viz., *major, glabra, rumbaiya, gracillis* and *macrocarpa* have been identified (Chandel *et al.* 1988). Rice bean is largely a self-pollinated diploid (2n = 22) crop but some natural cross-pollination has also bean reported (Sastrapadja and Sutarno, 1977; Singh and Sarma, 1993). Originally the rice bean was described as *Phaseolus calcaratus* Roxb (Baker, 1879) but recent taxonomy retains this species under genus *Vigna* (Verdcourt, 1970, 1971).

Distribution and Adaptation

Rice bean is a native of South and South East Asia (Ohwi, Jisabura, 1965). As a cultigen, rice bean occurs in India, Myanmar, Malayasia, China, Korea, Indonesia and Phillipines (Chandel *et al.,* 1988). It is also cultivated to a limited extent in West Indies, USA, Asutralia and East Africa (Burkill, 1935), Java, Fiji, Bangladesh, Srilanka and Nepal (Rachie and Roberts, 1974). The cultivars are well adapted to sub-tropical dry to moist climate. The best performance is obtained under 24–28°C temperature with 1500-2000 mm rainfall.

In India, its distribution is mainly confined to the tribal regions of north eastern hills and hilly tracts of Western and Eastern Ghats (Arora *et al.,* 1980). In North Eastern states of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura it is predominantly grown as rainfed in mixed farming system under shifting cultivation or in kitchen gardens and backyards (Sarma *et al.,* 1995). It is grown only on a limited scale in eastern peninsular tracts (parts of Orissa and Chhotnagpur) and western peninsular tracts of southern hills. Sporadic cultivation of rice bean is also done in sub-temperate Western Himalaya in Kumaon hills of Uttarakhand and Chamba region of Himachal Pradesh. Though no information is available about exact area under this crop in India, but roughly it is estimated to be grown in around 15000 ha. Rice bean is also reported to grow wild in the Himalayas (Chandel, 1981) and in central China. Its adaptive polymorphism (Chandel *et al.,* 1988) is indicated from its wider distribution with climatic variation ranging from humid sub-tropical to warm and cool temperate climate and growing up to an elevation of 1500 m (Arora *et al.,* 1980; Chandel *et al.,* 1982a). Rice bean is believed to be of Hindustan origin (Vavilov, 1951; Zevan and Zhukovsky, 1975). The rich genetic variability and the evolution of present day landraces of rice bean may perhaps be due to the introgression and folk selection.

Uses

- Rice bean is a promising multipurpose crop with a good potential to be used as food, fodder, green manure and cover crop. The dried seeds are usually eaten boiled or as pulse. Young immature pods are used as vegetable. Immature pods and bean sprouts are highly recommended in the nutritional diet of the Philippines. Its seeds are also good for broiler ration (Gupta *et al.,* 1993).

- Whole plant can be used as forage for livestock. The foliage, green pods, immature

seeds and flowers are readily eaten by animals. Due to its luxuriant growth, it can be grown as mixed crop with millets , minor millets, cereals as well as grasses

- It is also grown as a green manure and is an excellent cover crop.
- In China, Japan and Korea, the beans are generally ground into flour and meal; beans are often boiled and eaten as soup.
- It is immune to Yellow Mosaic Virus (YMV), a prominent disease in green gram and black gram and thus can easily replace green gram in plains if short duration varieties are developed. The crop can also be used as a donor parent for incorporating disease resistance in other Vigna species.
- The nutritional quality of rice bean has been reported to be the best among all the traditional pulses (Arora et al., 1980; Chandel et al., 1978a, 1978b) on account of its high protein and appreciable quantities of two limiting amino acids : methionine and tryptophan (NAS, 1979a). It contains high quality of vitamins: thiamine, niacin and riboflavin. Calcium and iron contents are also appreciably high (Singh et al., 1980). Phytin-phosphorus which generally inhibits the phosphorus availability and lowers the protein digestibility in most of the Asian pulses is low in this bean.

Varieties for Hills

1. **PRR-1(PRR 8801):** The variety released in 1997 for hill region of Uttarakhand was developed at G.B. Pant University of Agril.& Tech., Hill Campus, Ranichauri, Tehri Garwal as a pure line selection from Jagdhar (Tehri) collections. Its gives an average grain yield 15.0 q/ha and matures, on an average, in 141 days (111-165 days). Growth habit is trailing and indeterminate with average plant height of 90 cm. Foliage colour is dark green and seed colour is bluish black. The seed weight is around 7.0 g. The variety is recommended for low input and rainfed conditions.

2. **PRR-2(PRR 8901):** The variety released in 1997 for Hill region of UP, HP and North Eastern states, particularly mid and high altitude areas was developed at G.B. Pant University of Agril.& Tech., Hill Campus, Ranichauri, Tehri Garwal through pure line selection from the Dargi collections in district Tehri Garhwal. The variety has bold, attractive and light yellow coloured seeds having field tolerance to Ascochyta and resistant to yellow mosaic disease. The plants are medium tall (84 cm), indeterminate and less branched. Stem is light purple and bears dark green leaves. It is suitable for timely sown and low input conditions. It gives good nodulation even under acid soil conditions. Protein content in grains (20.0%) is slightly higher than that of the local material (19.2%) and PRR-1 (19.4%). Mean seed yield in Advance Varietal Testing under All India Coordinated Trials over five years was 8.85q/ha. The seeds are bolder (10 g/100 seeds) than PRR-1. The maturity period of PRR-1 and PRR-2 is almost the same.

Varieties for Plains

1. **RBL-1** : The variety released in 1986 for Punjab state was developed at PAU Ludhiana as a pure line selection from the material collected from Rajasthan. Plants are semi erect, 30-50 cm tall, producing 50-150 cm long twining branches. Stem is light green, grooved, covered with short fine white hair. Leaves are trifoliate with 6-9 cm long leaflets. Seeds are light green with smooth seed coat. The variety gives an average seed yield of 16.0 q/ha. It matures in about 130 days and is resistant to diseases and stored grain pests.

2. **RBL-6 :** The variety released in 2000 for plains at national level was developed at PAU Ludhiana as a pure line selection from germplasm collections of district Nagaur, Rajasthan. Like RBL 1, the variety is medium tall, spreading and has intertwining branches. However, RBL 6 has wider adaptability than RBL 1. The average plant height is 92 cm. Seed colour is light green. The average maturity period is 116 days ranging from 106 to 122 days. The variety when tested across the country in plains gave an average seed yield of 13.33 q/ha. Like other rice bean varieties, RBL 6 is also resistant to yellow mosaic virus and most of the other foliar diseases under field conditions. Sometimes sporadic incidence of Macrophomina, root rot, blight, Cercospora leaf spot and root knot nematodes is observed in sandy and loamy sand soils. Some damage is also done by galerucid bettle (Flower/ blister beetle), hairy caterpillar and stemfly. RBL 6 takes about 28 minutes for softening of grains in cooking as against 23 minutes taken by mung bean variety ML131.

3. **RBL-35 :** The variety released in 2003 for plains, was developed at PAU Ludhiana as a pure line selection from germplasm collections of district Nagaur, Rajasthan. In Coordinated trials it gave an average seed yield of 11.65 q/ha and matured in 92 days, 10 days earlier than RBL 1 and RBL6. Growth habit is semispreading, viny and semi inter-twinining. Internodes are short. Pods are glabrous and slightly curved. Seeds are oblong, greenish brown with 6.2 g test weight.

4. **RBL-50 :** The variety released in 2003 for plains, was developed at PAU Ludhiana as a pure line selection from germplasm collections of district Nagaur, Rajasthan. In Coordinated trials it gave an average seed yield of 10.97 q/ha and matured in about 101 days. Pods at maturity are dark brown. Foliage is dark green. The seeds are oblong and green with 6.0 g test weight.

Promising genotypes and land races

1. **BRS 1 :** The variety identified in 2003 for north-west hills was developed at NBPGR regional station Bhowali as a pure line selection from local material. In Coordinated trials it gave an average seed yield of 14 .50 q/ha. Colour of its seed resemble with that of mash (urd).

2. **Naini:** The genotype, suited to Central Himalayas, was developed from IC 26973-A, a collection made from Imphal (Manipur). The genotype is a viny and tall of

about 160 cm height. It has about 3 main branches. The genotype flowers in about 80 days and matures in 150 days bearing about 75 pods / plant with average pod length of 10 cm. Each pod possesses about 10 seeds, green in colour with test wt. of 10.3 g/ 100 seeds. The average seed yield of this genotype is around 8.0 q/ha.

3. **Megha Rumbaija 1 (RCRB 1-6)** : A selection from Meghalaya local germplasm is suited to Meghalaya (NEH Region) . It gives seed yield of 18 q /ha and is tolerant to diseases.

4. **MNPL 1 and MNPL 2** : These cultivars give an average seed yield of about 22 q /ha and are suited to region of Manipur state. MNPL 1 is preferred by farmers due to its good taste and bold seeds.

Cultivation Practices

- Rice bean can be grown on a wide range of soils, ranging from sandy loam to heavy soils with climate varying from dry to moist. However like other pulses, saline and waterlogged soils are not suitable for this pulse also.It is sown in Kharif season with onset of rains. Therefore, the optimal sowing time for this crop in hills is the month of May and in plains 1st half of July.

- Application of N:P:K @ 20:40:20 kg / ha at the time of sowing is recommended for better yields. Sowing of seeds @ 8-10 kg/ha can be done by drilling seeds at 45-60 cm row spacing for viny and vigorous types and at 30-40 cm for erect types. Plant to plant distance at 10-15 cm can be maintained by thinning plants at 15-20 DAS (Days after Sowing).

- To keep the field free from weeds, either pre-emergent application of pendimethalin @ 1 kg a i / ha and one hand hoeing at 30-35 DAS or hand hoeing twice at 20 & 40 DAS is desirable.

- For viny types staking the plants gives an increase in yield by more than 20-25%.

- Intercropping rice bean with either maize or pigeonpea in 2: 1 row ratio in plains enhances rice bean equivalent yield and cost benefit ratio.

- Some times, the Meliod beetle or the red beetle (*Mylabris* spp.) causes a serious problem at the time of flowering and its control is immediately required in consultation with an entomologist. It is desired that manual collection of adults by nets and killing them in kerosinized water be practiced. Use of endosulphan 0.05 % (140 ml, Thiodon 30 EC) or carbaryl 0.1% (200g , Sevin 50 WP) at the flowering stage is also desirable.

Researchable Issues

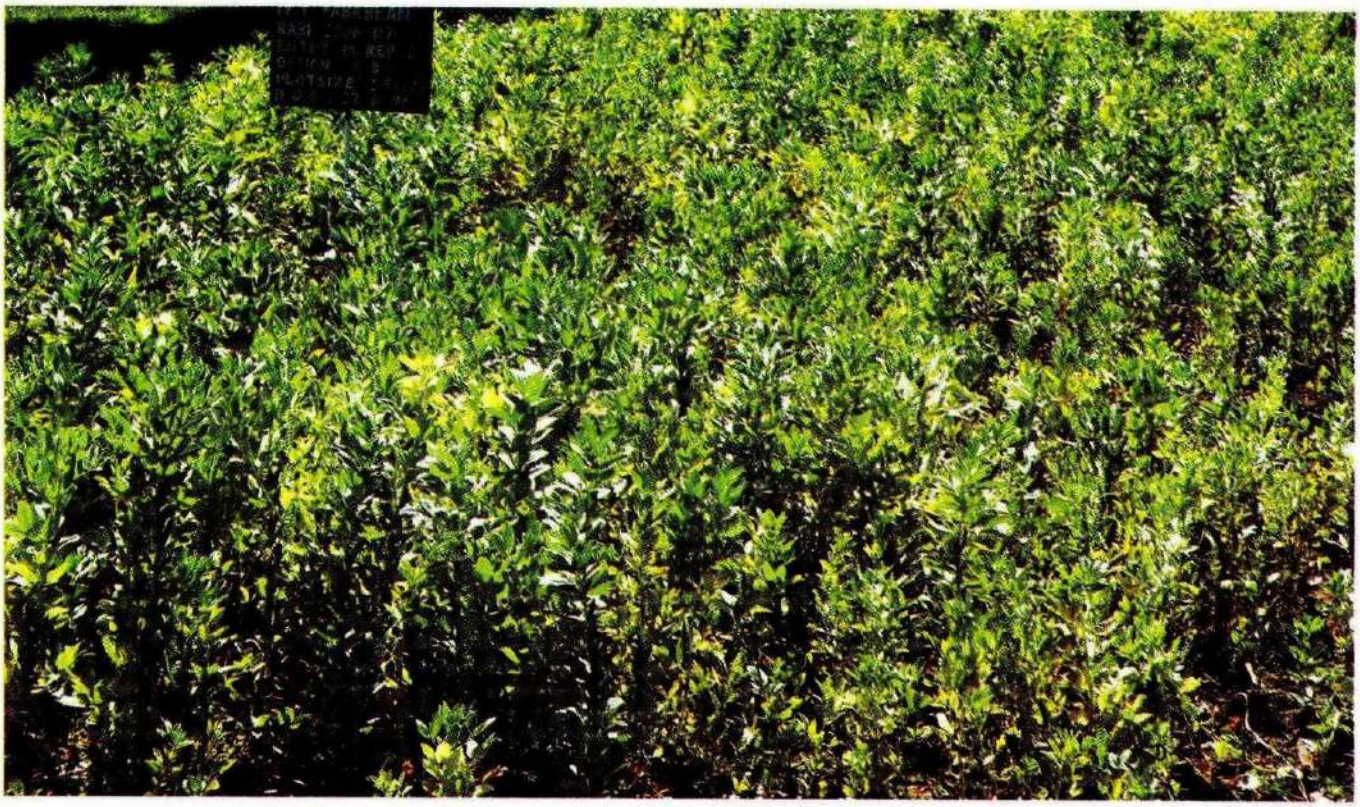
1. The crop has indeterminate growth and is of long duration. Therefore, it can not compete with conventional pulses of plains like green gram and black gram.

Therefore, efforts are required to develop determinate varieties with short duration to fit well in cropping systems in plains.

2. There are some compounds like tannins, phenols, protease inhibitors , off flavors in ricebean which render it unacceptable to consumers as compared to other pulses. This requires /either development of improved varieties or find out easy ways and means for processing seeds to lower down these compounds before consumption.

3. Flower beetle or the red beetle causes a great loss to its production by damaging the flowers. Therefore, measures should be standardized to control this menace.

4.2 FABA BEAN (*Vicia faba* L.)



Faba bean (*Vicia faba* L.), a legume crop of family Fabaceae has two subspecies: paucijuga and eu-faba. Within eu-faba, there are three commonly recognized varieties; the large seeded major, the intermediate equina and the small seeded minor. Faba bean is a partially allogamous species (2n = 12, 14), known by many names (Bond 1979). *Vicia faba* vars. equina and minor are usually referred as field beans in Europe, while large seeded major is known as broad beans. In field beans, winter and spring-sown equina types are known as horse beans and the term tick bean is often used to denote the small seeded variety minor. Broad beans are sometimes divided into long pod and Windsor beans. Usually, broad beans refer to the whole species *Vicia faba* L also. Thus, considerable confusion had resulted from this multiplicity of nomenclature and in order to standardize the terminology, now the name 'faba bean' has been accepted internationally to denote the entire species. In India, faba bean is known by various names, such as, *Bakla, Anhuri, Kala matar* in Hindi; *Raj-rawan* in Urdu and *Kadu*

huralikayee in Kanada. It is also known by various local names in different parts of the country as *Baklasem* in Delhi; *Chastang, Kabli bakla, Mattzrewari, Raj-rawan* in Punjab; *Katun* in Kashmir; *Chastang ralum* in North-West Himalayas; *Nakshan* in Ladakh; *Bakla* in Kumaun and *Hende mater* in Mundari region.

Distribution and Adaptation

The place of origin and the progenitor of faba bean still remain uncertain. Linnaeus (1753) in his book '*Species Plantarum*', stated the origin of faba bean as Egypt, while De Candolle (1886) was of the view that this crop originated either in North Africa or in a region south of the Caspian Sea where it was observed growing wild by the Russian traveler Lerche. Abdalla (1979) considered its origin in Egypt. But, studies have revealed that faba bean probably originated in West (Cubero 1974) or Central Asia (Ladizinski 1975).

Faba bean is the fourth important pulse crop of the world after dry beans, dry peas and chickpeas (Hawtin and Stewart, 1977). The major faba bean growing countries are China, Egypt, United Kingdom and Syria. About 70% of total global production is contributed by China alone. It is also an important crop in North Europe, the Meditetrranean Basin and Latin America (Hawtin and Hebblethwaite, 1983). In India, its cultivation is confined as a minor crop in Himalayan hills, Bihar, Eastern Uttar Pradesh and around cities and towns where faba bean pods fetch a good premium. Faba bean thrives well under irrigated conditions and can withstand high water table and soil salinity which have posed severe threat to successful cultivation of chickpea (Lockerman *et al.*, 1983)

Faba bean is a temperate crop and requires cool climate and a long season. Even in United States the summers are often too hot and the winters too cold for its cultivation. It can be grown towards the edge of tropics as a winter crop, as is done in the Northern Sudan and Myanmar (Burma) or at high altitude as in Latin America. In India, it is cultivated throughout the Gangetic plains in winter season. Sufficient soil moisture is necessary as it is unable to withstand drought. It grows well under irrigated conditions and can tolerate even water stagnation to some extent. Its nitrogen fixation ability is also very high as it can fix up to 500 kg N/ha, as reported from International Centre for Agricultural Research in the Dry Areas (ICARDA), Syria.

Uses

- Faba bean seed is used both for human as well as livestock feed. In Europe, faba bean is extensively cultivated for both, immature and mature pods as human food.
- It is cultivated mostly for cattle feeding in the United States of America. In Canada, it is used with corn to make silage called "Robertson Mixture".
- It is considered an important food crop in Latin America. However, its cultivation has not so far gained popularity as a pulse crop. Pods are mainly used as vegetable,

either green or dried, fresh or canned.

- Roasted seeds are eaten like peanuts.
- Beans can also be used in the form of soup. The seeds can be processed like soybeans to produce a range of high protein products.

Varieties

VH 82-1 (Vikrant) : The variety released in 1998 was developed at HAU, Hissar as a pure line selection from local material of Meerut (U.P.). This is first variety identified at national level for seed purpose. The variety is suitable both for irrigated as well as semi irrigated conditions specially in Northern plains. The variety matures in about 140-150 days. It has erect plant type with green leaves, bears white flowers with a black dot on keel. Seed shape is roundish and smooth having slightly depressed surface with a black hilum and creamy colour. Protein content in the seed is 24.85%. The variety has more tolerance to $Cl^{/}$ and $SO_4^{//}$ salinity as compared to chickpea.

Cultivation Practices

- Faba bean can be cultivated on a wide range of soil types.
- In plains it is cultivated in winter season and the optimum sowing time is in the month of October. Whereas, at higher elevation, it is cultivated in summer and is sown in the months of March-April. Sowing with the seed rate of 100-125 kg/ha can be done by drilling the seeds in rows spaced at 20-30 cm. The plant population can be maintained by keeping plant to plant distance at 10 cm after thinning at 15-20 DAS.
- Application of fertilizer dose of N: P: K @ 40: 60: 0 kg/ha, at the time of sowing, is recommended to get better yields.
- To keep the field free from weeds, 1-2 hand hoeings at an interval of 1 month are essential.
- Three irrigations, one as pre-sowing, second at flowering and third at pod filling stage are sufficient to have a good crop.
- To avoid shattering, harvesting should be done at 75-80% pod maturity.

Researchable Issues

1. The major limiting factor in faba bean production is the unreliability of seed yields on account of its pollination system and effect of biotic and abiotic stresses. Faba bean is severely affected by leaf blight , charcoal rot and several other diseases. Therefore, there is a need to develop stable varieties resistant to diseases / pests and abiotic factors.
2. At maturity, the pod shattering causes a great loss in seed yields. Therefore,

there is need to develop varieties with uniform maturity and resistant to shattering.

3. The seeds contain a number of anti nutritional factors like tannins, saponins, glucosides, vicine, convicine and trypsin inhibitors which render them unacceptable for safe consumption. Therefore, there is a need to evaluate the germplasm to develop superior varieties with low level of anti nutritional factors or find means and ways to detoxify these factors before consumption.

4.3 ADZUKI BEAN (*Vigna angularis* (Willd.) Ohwi & Ohashi)

Adzuki bean [*Vigna angularis* (Willd.) Ohwi and Ohashi], syn. [*Phaseolus angularis* (Willd.) Weight], (*Dolichos angularis* Willd.) and [*Azukia angularis* (Willd.) Ohwi] of Leguminosae family is an erect, bushy annual, usually 30 - 40 cm tall, determinate, late maturing, slightly viny with trifoliate leaves and short, axillary inflorescence having 6 - 12 clustered bright yellow flowers. Pods are cylindrical, 6 - 12 cm long with 4 - 12 seeds and straw coloured with blackish or brown forms and constricted between seeds. Seeds are cylindrical to cordate with smooth, wine red, occasionally buff, black or mottled seed coat. Adzuki bean is a self pollinated crop with 2n = 22 (Bhagmal, 1994).

Uses

- Adzuki bean has a wide variety of uses. The dried seeds are used for human food, either cooked whole or made into meal, used in soups, cakes or confectionary.
- Beans may be popped like corn, used as a coffee substitute or as sugar candy.
- Flour is used for making shampoos and face creams.
- In Japan, it is largely used as human food in the form of meal or paste. In India, it is used, as a pulse, either whole or split (Thomas *et al.* 1974).
- Sprouted beans are used as vegetable.
- The crop is also reported to be grown for forage and green manuring purposes in China and Japan.
- Adzuki bean seeds have medicinal properties and are reported to be used in the treatment of kidney trouble, constipation, boils, abscesses, threatened

miscarriage, difficult labour, retained placenta and non-secretion of milk.

- Its leaves are said to be helpful in lowering fever and its sprouts are used to treat threatened abortion caused by injury (Sacks, 1977).

Distribution and Adaptation

Adzuki bean, unlike other cultivated *Vigna* species, occurs mainly in temperate and sub-temperate regions. It is cultivated in Japan, Korea, China and Manchuria. In India, its cultivation is confined to North-Eastern and Northern Hill zones.

Although a short day plant, day neutral responses are reported in Korean and Japanese lines. In Japan, it has been reported to be grown in an area of about 1,20,000 hectares, stands second to soybeans and commands higher prices than any other bean. The most commonly cultivated cultivars have maroon seeds. Like soybean, there seems to be latitudinal adaptation in day length sensitivity. Early maturing southern cultivars are more sensitive to short days as compared to northern cultivars.

Soil temperature above 16°C is congenial for germination of adzuki bean, while temperature range of 15 - 30°C is required for good growth. On volcanic soils, the crop has been reported to be sensitive to boron and nickel toxicities. It has been observed to tolerate mean annual temperature of 7.8 - 27.8°C and pH 5.0 - 7.5. Adzuki bean can grow in all types of soil from light to heavy and is more tolerant to heavy rainfall than other grain legumes. It is reported to tolerate annual precipitation of 500 - 1700 mm.

Promising genotypes

There is no released variety in adzuki bean. However, selections made from the collections of different regions and evaluated in All India Coordinated Research Network on Underutilized Crops over the locations and years have led to identify some of the good genotypes. These are:

SMLAB 4 : Selection made at NBPGR Regional Station gave an average seed yield 14.4 q/ha in AICRP trials.

SMLAB 6 : Selection made at NBPGR Regional Station gave an average seed yield 15.3 q/ha.

SMLAB 9 : Selection made at NBPGR Regional Station gave an average seed yield 15.1 q/ha.

SMLAB 10 : Selection made at NBPGR Regional Station gave an average seed yield 14.2 q/ha..

HPU 51 : Average seed yield recorded in AICRP trials is 14.1 q/ha. It has been seen to possess field resistance to *Cercospora, Colletrichum* and *Aschochvta* in Himachal Pradesh

Cultivation Practices

- Adzuki bean can grow well in any type of soil, from sandy to clay. However, the crop does not grow well in highly acidic conditions.
- It is sown with the onset of monsoon in the months of May - June. Plants are spaced 30 cm apart in rows at 60 - 90 cm distance. In some places, a closer spacing of 30x30 cm is also adopted. Seeds are drilled 2.5 cm deep using a seed rate of 10-30 kg/ha. A high seed rate is generally used for direct seeding in rice stubbles to reduce weed problem.
- A fertilizer dose of N:P:K @ 25 : 50 :30 kg/ha is recommended for soils having medium in fertility.
- To keep the field free from weeds, two weedings at 20 and 40 days after sowing (DAS) is beneficial for good growth and yield.
- Several pests and diseases are reported to affect adzuki bean crop. Fungal and bacterial diseases like leaf blight, leaf blotch, rust, charcoal rot, anthracnose, leaf spot, stem rot and powdery mildew are of considerable importance. Similarly, viral diseases like adzuki bean mosaic virus and cucumber mosaic virus occur widely in Japan. Amongst the insect pests, pod worm, Japanese butter bean borer, cut worm, corn seed maggot, aphids and soybean cyst nematode are important. The weevils damage the seeds in storage.
- Adzuki bean ripens evenly and its pods do not shatter. Thus, it is amenable to mechanical harvesting by mower or bean harvester.

4.4 WINGED BEAN (*Psophocarpus tetragonolobus (L.) DC.*)

Winged bean (*Psophocarpus tetragonolobus*), commonly known as the Goa bean, Four angled bean, Manila bean, Asparagus pea, Princess pea and Kacang botol (Malaysia), is a tropical legume native to Papua New Guinea. It belongs to family Fabaceae/ Legminosae and tribe Phaseoleae. It grows abundantly in hot, humid equatorial countries, from Philippines and Indonesia to India, Burma and Sri Lanka. It does well in humid tropics with high rainfall.

The winged bean plant grows as a vine with climbing stems and leaves, 3-4 m in height. It is an herbaceous perennial, but can be grown as an annual. It is generally taller and notably larger than the Common bean. The bean pod is typically 15-22 cm (6-9 inches) long and has four wings with frilly edges running lengthwise. The skin is waxy and the flesh partially translucent in the young pods. When the pod is fully ripe, it turns to ash-brown color and splits open to release the seeds. The large flower is a pale blue. The beans are similar to soybeans in both use and nutritional content (29.8% to 39% protein). It is a self pollinated crop with 2n=18, but there are several other reports where chromosome number has been indicated to be either 2n=16 or 2n=20 or 2n=26 (Bhagmal, 1994). It is sensitive to drought, frost, salinity and water logging.

Uses

- This bean has been referred as "one species supermarket" because practically the whole plant is edible. While the beans are used as a vegetable, the other parts (leaves, flowers, and tuberous roots) are also edible.
- The tender pods, which are the most widely eaten part of the plant, can be harvested within two to three months of planting. These pods are cooked with chillies or eaten with fish and meat in many countries. The flowers are often used to color rice and pastries. The flavor of the beans has a similarity to asparagus. The young leaves can be picked and used as a leafy vegetable, similar to spinach. Tender fibreless pods used as vegetable contains nearly 3 % protein and are rich in calcium, iron, thiamine and ascrorbic acid.
- The roots can also be used as a root vegetable, similar to the potato and have a nutty flavor. They are also rich in protein much more than potatoes.
- Seeds contain protein and oil similar to that of soybean and are rich in antioxidants and tocopherol. After extraction of oil, the cake can be used as cattle feed. The oil can be used for cooking, illumination and soap making.
- The dried seeds can be used as flour and also to make a coffee-like drink.
- Each part of the winged bean is a source of vitamin A and other vitamins.

Distribution and Adaptation

Winged bean is regarded as a crop of hot humid tropics. The crop thrives well from sea level to 2000 msl. Winged bean is distributed throughout Asia and West Africa. In India, it is confined to humid sub-tropical parts of North-Eastern region comprising

states of Tripura, Manipur, Mizoram, Nagaland and Assam. It also occurs sporadically in ghats of Maharashtra, Karnataka, Kerala and Orissa

Winged bean is mostly cultivated as a backyard or garden crop and consumed locally. Therefore, reliable estimates of its area and production are not available. However, it is grown as a field crop for seed and tubers in Papua New Guinea and Myanmar. Seed yields >20 q/ha and green pod yield >350 q/ha have been reported from Papua New Guinea and Malaysia, respectively. In India, yields reported from experimental plots are of the order of 7 - 15 q/ha for seed, 40 - 95 q/ha for green pods and 48 - 60 q/ha for tubers. There is an ample scope of improvement in yields by use of improved cultivation practices.

Varieties

AKWB-1 : The variety released in 1991, was developed as a pure line selection from germplasm accession EC 114273 B ex Indonesia (Java) at NBPGR regional station Akola. AKWB-1 is the first variety released in India as a vegetable type for winged bean growing areas. However, the variety can be used for dual purpose. Average pod and seed yield under normal conditions is 71.42 q/ha and 8.38 q/ha respectively. It is a pole (Indeterminate) type with its vine length > 2.5 m. Flowering comes in about 69 days and pods are ready for first picking in about 90 days and goes up to 175 days. Pod length and width is about 10.5 and 1.2 cm respectively. Seed colour is purplish black and has 27 g test weight. Since the crop is viny with indeterminate habit, staking is needed for optimum crop growth and yield.

Promising genotypes and land races

Apart from the above released variety there are other improved genotypes which have performed well in Indian plains. Based on the average performance tested over locations and years in All India Coordinated Research Network on Underutilized Crops, following genotypes were selected for better pod and seed yield:

EC 178313 : Average seed yield recorded in AICRP trials 8.84 q/ha with 165 days to maturity.

IC 026945 : Average seed yield recorded in AICRP trials 8.81 q/ha with 163 days to maturity

EC 142665 : Average seed yield recorded in AICRP trials 8.74 q/ha with 163 days to maturity.

EC 178331 : Average seed yield recorded in AICRP trials 8.41 q/ha with 163 days to maturity.

Dwarf Mutant : Developed at UAS Bengalore. Average seed yield recorded in AICRP trials 8.22 q/ha with 161 days to maturity.

Mysore Local : Developed at UAS Bengalore. Average seed yield recorded in AICRP trials 7.69 q/ha with 163 days to maturity.

Cultivation Practices

- The plant is one of the best nitrogen fixers with the help of the soil bacterium *Rhizobium* and therefore, the plant requires very little or no fertilizers.
- Winged bean can be grown on a range of soils and is grown typically on well drained acid soils with pH range of 4.3-7.5.
- It is reported to tolerate annual rain fall of 700-4100 mm and annual temperature of 15.4-27.5° C (Duke, 1981).
- It is normally sown with the on set of monsoon in a well prepared soil
- The seeds have a hard coat and it requires presoaking before planting to hasten germination. The plant grows very quickly, reaching a length of four meters in a few weeks.
- The seeds can be sown at inter and intra row spacing of 90 x 90 cm for pods and 45x45 cm for seed purpose. This may require a seed rate of about 15 - 20 kg / ha. However, closer spacing of 30 x 20 cm can be followed for dwarf mutant types.
- Though, the crop is highly nodulating but a fertilizer dose of N:P @ 20:40 kg/ha at the time of sowing should be given for initial vigor.
- To get better yields, staking of plants and one hand weeding at 15-20 DAS is required. Its plant is sensitive to frost, drought, salinity and water logging. It will not flower if day length is more than 12 hours.
- In India, there are no major reports of incidence of diseases and insects pests. However, false rust (*Synchytrium psophocarpi*), leaf spot (*Pseudocercospora psophocarpi*) are the important fungal diseases. Insects such as *Maruca testulalis* and lady bug (*Hermoceplachna signatipennis*) and root knot nematodes (*Meloidogyne javanica* and *M. incognita*) may affect the crop. Suitable plant protection measures need to be taken to minimize the yield losses.

Researchable Issues

1. Presence of anti nutritional factors like trypsin and chymotrypsin inhibitors affects its utilization adversely. Therefore, either the varieties with low level of these factors be developed or easy processing methods be developed for their consumption.
2. For its easy cultivation, annual, non staking and non shattering varieties with determinate habit and uniform maturity may be developed.

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VEGETABLES 5

Research work under AICRP (Underutilized Crops) has been carried out on two vegetable crops namely Kankoda and Kalingara. The first one has medical significance, whereas the second has multifarious uses and is hardy in nature.

5.1 KANKODA (*Momordica dioica* (Roxb.) Ex. Willd.)

Kankoda or the spine gourd (*Momordica dioica* (Roxb.) Ex. Willd.), is also known as Kaksa or Golkandra in Hindi, Ban Karela in Bengali, Kartoli in Marathi, Ankara in Telugu, Tholoopavari in Tamil, Karlikan in Kannada, Bhat Karela in Assam and Kakaura, Kirara or Dhar Karela in Punjab, is a perennial dioecious climber of cucurbitaceae family with tuberous roots. Its leaves are ovate, entire and deeply 3 – 5 lobed. Flowers of kankoda are solitary yellow in colour and fruits ovoid or ellipsoidal, 2.5 to 6.3 cm long, shortly beaked, densely echinate with soft spines and irregularly corrugated (WOI, 1985). Male flowers are conspicuous by having globular calyx. The aerial parts die during winter and sprout from under ground tubers with the onset of rains. The diploid species has chromosome number 2n = 28. Another cultivar found naturally in Khasi and Jaintia hills of Assam and Darjeeling has chromosome number 2n= 56 (tetraploid). Its leaves, petiole, peduncle, sepals, corolla and fruit are larger than that of diploid cultivar. This cultivar is suitable for commercial cultivation. It sprouts in spring from under ground tubers, thereby giving an early crop in irrigated areas. A cross between diploid and tetraploid produces a triploid, which has characters intermediate between the diploid and tetraploid cultivars.

Another species, *Momordica cochinchinensis*, probably a native of Vietnam, is found in Taiwan, Hong Kong, China and India. It has very large fruits (9.5 cm x 12.5 cm, wt. 500 g). Seeds are numerous, 2.2 cm x 1.6 cm x 0.5 cm in size, ovoid, much

compressed and sculptured on both sides. The leaves of *M. cochinchinensis* are deeply lobed and have umbilicate glands in lamina base, whereas those of *M. dioica* do not have such glands. The vines produced from seeds in *M. cochinchinensis* do not bear fruits.

Distribution and adaptation

Kankoda is found all over India from Tamil Nadu to Himalayas upto an altitude of 1500 m. The plant is sometimes found growing wild and is common in hedges in warm, humid places. It grows wild in the hills of Rajmahal, Hazaribagh and Rajgir in Bihar, hilly region of Pune district in Maharastra and hilly areas of Gujarat and western Rajasthan.

Kankoda is not cultivated on large scale in India. While diploid is collected from hill forests, tetraploid is cultivated in Assam and Nadia district of West Bengal. Tribal people in several states like Orissa, Chhatisgarh, Jharkhand, Gujarat cultivate this vegetable in their backyards. The vegetable is very costly and is always in demand. The crop is not grown on large scale because of want of sufficient planting material and lack of appropriate cultivation techniques (Mishra and Sahu, 1983).

Uses

- Kankoda is often planted for its fruits which are used as vegetable. The fruit is rich in ascorbic acid (275.1 mg/ 100g) and also contains iodine (0.7 mg/ 100g).
- The vegetable is ideal for patients of diabetes and gout. The consumption of green fruits and tubers, stimulate the activities of pancreas and control the level of sugar. Its green fruits contain 12-14% protein.
- Unlike *M. charantia var. muricata* (bitter gourd), it is not bitter in taste. The seed kernel, on extraction with carbon tetrachloride, yields 33.5 % of a dark brown semi drying oil, which may be used in paint and varnish industry.
- The roots, which often weigh around 500 g are astringent and contain an alkaloid. The roots of female plants are larger than those of the male and are preferred for medicinal use. They are applied in bleeding piles and used for bowel infections and urinary complaints. The root is pasted and applied over the body as a sedative in fevers.

Variety

Indira Kankoda 1 (RMF 37) : The variety released in 2006 for states of Chhatisgarh UP, Jharkhand , Orissa & Maharashtra was developed at RMD College of Agriculture & Research Station Krishi Nagar, Ambikapur (IGAU, Raipur) through mass selection from local material of forest areas of Surguja District of Chhattisgarh. In general, the variety is resistant to major diseases and pests. The average fruit yield of the variety has been recorded to be 20.98 q/ha. Fruit setting starts in 30-35 days if planted from tubers (Category I) and 55-60 days in first year if planted from seeds (Category II). Days to first

picking takes 40-45 days and goes up to 110-115 days (3-4 pickings) under category I and starts in 75-80 days and goes up to 130-135 days (2-3 pickings) under category II. Green fruit yield under category I is 25-30 q/ha as against 10-15 q/ha under category II. Plant type is viny with vine length of 2-3 m and needs staking for good yields.

Cultivation Practices

- Normally, tribal people grow diploid kankoda in hilly areas all along the hedges. However, it can be cultivated on farm lands also. The plants require temperature of 30-35°C and humidity of 80-85 %. It can be grown on a variety of soils but sandy loam soil rich in organic matter is ideal for its growth. Since, this crop is grown during monsoon, deep ploughing is to be done across both directions of the field before monsoon for final preparation of the field.

- Basins of 30-40 cm diameter with 30 cm depth are prepared at an intra and inter row spacing of 1.5 x 2.0 m. Each basin is supplied with 2 kg compost and fertilizer doze of 30g Urea, 100g SSP and 20g MOP along with 3g furadan before sowing and 30g urea at 20-30 DAS. Irrigation in the basin is applied one day before sowing.

- The planting material can either be seed or stem cutting or tuberous root. Since the crop is dioceous, proper ratio of female and male plants is a pre requisite for better yields. While planting through seeds, it is required that seed should be 9-12 months old, the seeds should be scarified and wrapped in moist gunny bags for about 24 hrs or be treated with 1 % sulphuric acid. Seedlings can be raised in seed bed of the 1-3 m width with 0.30 m height formed by a mixture of well drained soil, sand and FYM in ratio of 1:2:2. Then 2-3 seedlings along with tubers are planted in each basin. To keep desired female: male ratio of 9:1 in each row, undesired plants are uprooted from each basin at the time of flower initiation. Though, this is easiest method of sowing but there are certain disadvantages in this method of sowings: (1) Since fruits are sold on commercial scale, seeds are not available on large scale, (2) seeds have low germination and plants raised from seeds give poor yield during 1st year, (3) it is cumbersome to maintain the desired female: male ratio when planted through seeds.

- The planting either through stem cuttings or tuberous roots is desirable. Semi mature 2-3 cm long stem cuttings with one leaf and 2-3 nodes are prepared with slanting cuts and put in poly bags after dipping lower 1cm portion in hormonal solution (IBA 750ppm) for about 10 minutes followed by dipping in some fungicide. If topmost portion of the vine is being used as cutting then the hormone treatment can be dispensed with. Poly bags can be put under moist and shade conditions for easy rooting.

- The rooted cuttings are transferred to basins either on a cloudy day or in the evening followed by light irrigation daily till new leaf emerges. These rooted cuttings with known sex are planted in the desired sex ratio of 9 female:1male.

- For propagation through tubers, the tubers are to be collected, washed with clean water, treated with fungicide like Bavistin and stored in dry and cool place for 3-4 months and then planted in month of May-June depending upon the availability of water.

- Flowering in *Momordica* dioica tetraploid occurs on 9-23 nodes on main stem, 6-13 on secondary branches and on node 1 onwards on the tertiary branches. Therefore, primary stem should be cut after node 23 and secondary branches after node 13.

- Fruit set in kankoda is unsatisfactory. The average fruit set in tetraploid is 14.70%, the highest being 22.8% in mid August. The fruit set in diploid is still worse because the flowers open during evening and night hours when natural pollinating agents are fewer. To enhance yield, it is desirable to pollinate the flowers in the evening by using small camel hair brush or keep an apiary as bees are more efficient pollinating agents.

- To keep the crop safe from fungal diseases, it is recommended for spray of bavistin(1g/litre water) at fortnightly intervals.

- The fruits can be covered by polythene bags to protect from fruitfly.

- To get better fruit quality the plants may be staked and given strong support.

Researchable Issues

1. Since propagation through seed will be an easy way of planting the crop, studies are required to be undertaken to standardize the practices for improving the seed germination percentage, better tuber development in 1st year and identification of male and female plants at an early stage.

2. To enhance pollination and fruit set, suitable techniques are required to be standardized.

5.2 KALINGADA [*Citrullus lanatus* (Thunb.)]

Kalingada [*Citrullus lanatus* (Thunb.) Mansfeld], commonly called local Matira or the wild watermelon, is a hispid drought hardy cucurbitaceous creeper. Stem is herbaceous and has a length of about 3 m. Kalingada and matira are the different forms available as local types/ land races of watermelon which are less sweet and have small sized fruits. Generally, the fruits of these forms/local types are used as vegetables and for extracting seeds for magaz purpose, these forms have different seed characteristics. The plants are monoecious with

male and hermaphrodite flowers. Some genotypes also have male and female flowers. Seeds are used either for 'magaz' or extracting oil. Kalingada fruits are globose, sub globose and ellipsoid with 15-20 cm diameter weighing about 0.25 to 5.0 kg, smooth, green mottled with irregular bands of dark green or uniform in colour. Pericarp is hard but not woody, pulp solid white, pink or reddish pink. Seeds are numerous, 6-10 mm long, pyriform, compressed with dark brown, black, pink, white or mottled in colour.

Distribution and Adaptation

Though cultivated in the warmer parts of the world, it is a true native of sandy dry areas of Tropical Africa. The plant grows in hot and dry situations on any ordinary soil provided there is sufficient moisture. Generally, it is grown as rain fed crop and does not withstand water logging and frost. In India, it is an important crop in dry areas of Gujarat and Rajasthan and is grown in an estimated area of about 6000 hectares with annual production of about 60000 q of seeds.

Uses

- It is a multipurpose plant species grown mixed with sorghum, pearlmillet and castor as a companion crop. The tender fruits are used as vegetable.
- The seeds are the unconventional source of edible oil (35-37%) which is also used as illuminant. The roasted seeds are eaten like groundnut. The seeds are used as food, being sometimes ground and baked into bread. They are also parched and eaten with other grains. The seeds are considered to be cooling and diuretic. Presently, the seeds of karingada and matira are also being used for getting "Magaz" which in turn is being used in sweets, mukhwas (mouth fresheners), beverage "thundai" and to some extent in Unani medicines.
- The seed cake is free from alkaloids and can be used as cattle feed.
- When grown as mix crop, kalingada not only conserves the soil moisture but also enhances the productivity of the companion crop.
- Pulp (60% of whole fruit) usually sweet is generally eaten fresh. It can be used for preparing pickles and sweets. The fruit juice forms a cooling and refreshing beverage highly valued during summer. It is reported to have diuretic properties.
- A wild form known as *Kirbut*, possesses bitter flesh and is used as purgative. A variety, citron, with white solid flesh, is grown in America for making jams, jellies and preserves because of its high protein content.

Variety

Gujarat Karingada-1 (SKNK-7) : The variety released in 2002 for arid/semi arid areas of Gujarat was developed at GAU Sardar Krushinagar through mass selection in the material collected from village Zalakarja, Distt Banaskantha. The variety gives average seed yield of 10.20 q/ha. The average number of fruits per plant varies from

8-12 with average fruit girth of 41 cm. The average vine length is 5 m. Its test seed weight is about 6.20 g. The estimated oil, TSS and protein values are 37.0, 3.4 and 18.0 % respectively.

Cultivation Practices

- Kalingada is normally grown on sandy river beds during summer or in well drained light soils during monsoon.
- It is usually sown as mixtures with sorghum, pearl millet, dew gram, cowpea and green gram on the onset of monsoon in the month of June – July. However, as a pure crop it can be sown at a spacing of 3m x 1m. It has been observed that growing every third row of kalingada in pearl millet gives a benefit cost ratio of 2.28:1.
- In pure crop, a modest dose of 25 kg N /ha is recommended for better fruit and seed yield.

OIL SEED CROPS 6

This group comprised of crops providing edible and non edible oils. Among crops providing edible oil, perilla is mainly grown in hills, whereas simarouba is an introduced plantation crop and is still under process of commercialization in India. Among non edible crops tumba is a native hardy crop grown in deserts and provide oil for soap industry. Jatropha is being exploited as bio fuel and jojoba oil used as base for cosmetics.

6.1 PERILLA (*Perilla frutescens* L.)

Perilla (*Perilla frutescens* L.), commonly known as Bhanjira in Hindi, Ban Tulsi in Bengali, Arim, Angami and Kenia in Assam and Jutela in Kumaon, is an aromatic, bushy annual plant having height up to 150 cm and belongs to mint family Lamiaceae (Labiate). Its leaves are broadly ovate, acuminate, coarsely serrate or crenate. Inflorescence as axillary and terminal raceme is compact having small white flowers. Each flower is subtended by a bract and has tubular calyx. The nutlets, commonly called seeds, are rounded and pale brown with reticulate markings (WOI, 1985). These nutlets are borne in a tubular calyx.

Distribution and Adaptation

It is native to Mountaneous areas of China and India. It is distributed throughout the Himalayas up to an altitude of 3500 m, Sino-Japanese region and south-eastern

Asia. Average yield of seeds in Japan is 16.80 q/ha. In India, the plant is frequently grown in Himalayas and Assam by the local people but there is no organized cultivation of the herb.

Uses

- The herb is cultivated in China and Japan for its seeds which contain 30-51% oil having commercial importance. Perilla oil finds extensive use in paints and varnishes, core oils, printing inks, oil papers, water proof cloth, artificial leather, cheap lacquers, enamels and lindenm.
- The leaves and flowering tips of perilla are used as flavourings.
- In USA, the oil is mixed with soybean oil for protective coatings.
- In India, the oil is utilized for edible purposes. In hilly areas of Uttaranchal, seeds are used in "Taraka" for giving a flavor to vegetables and are eaten as freshener also. The seeds contain 6.3% moisture, 23.12% protein, 45.07% fatty oil, 10.28% N free extract, 10.28% crude fibre and 4.64% ash. Presence of nicotinic acid (3.90 mg/100) and a substance having anti oxidant activity is also reported (Phogat and Sharma, 2000).
- In Korea, its leaves are used as food and seeds used to make edible oil.
- In Japan, its leaves are used for colouring plum preparations. They contain an anthocyanin, perillanin chloride, which on hydrolysis yields probably delphinidine and glucose. The oil is chiefly used for the preparation of the L-antialdozimo of perilla dehyde which is 2000 times as sweet as sugar and 4 to 8 times as sweet as saccharin. The Japanese government permits the use of this derivative as a substitute for maple sugar or liquorice in sweetening tobacco. The cake is used as a fertilizer for mulberry and rice. It contains 0.56% calcium, 0.47% phosphorus and 6.14% nitrogen. The seed cake is rich in protein and may be used as a cattle feed. The cake on an average has 38.4% protein, 8.4% fat, 16.0% N-free extract, 20.9% crude fibre, 34.2% digestible protein and 61.4% total digestible nutrients.
- *P. frutescens* var. *crispa* form *viridis*, locally called 'Ao shiso' in Japan, yields 0.3-13% volatile oil and citral on dry weight basis. The oil and citral are maximum at the beginning of flowering. The oil possesses a haylike odour. It is sparingly used as a flavouring agent in table sauces, confectionery and dentrifices. It possesses strong antiseptic action and is used as an antimildew agent.
- The herb is reported to possess sedative, antispasmodic and diaphoretic properties and is prescribed for cephalic and uterine troubles. *P. frutescens* var. *crispa* is used in mixtures administered for cough and lung infections.

Promising genotypes

No variety has been released in India. However, the selections from the collections

made from different regions and tested under All India Coordinated Network Project on Underutilized Crops over years and locations indicated some of the promising genotypes for Hill Region. These are:

IC 006441 : Selection made at NBPGR Regional Station Shillong, Meghalaya gave an average seed yield of 13 .0 q/ha in AICRP trials.

IC 003913 : Selection made at NBPGR Regional Station Shillong, Meghalaya gave an average seed yield of 8.8 q/ha in AICRP trials.

IC 211608 : Selection made at NBPGR Regional Station Shillong, Meghalaya gave an average seed yield of 8.3 q/ha in AICRP trials.

BDS 1647 : Selection made at NBPGR Regional Station Shillong, Meghalaya gave an average seed yield of 8.0 q/ha in AICRP trials.

IC 006447 : Selection made at NBPGR Regional Station Shillong, Meghalaya gave an average seed yield of 7.9 q/ha in AICRP trials.

Cultivation Practices

- Perilla grows well in well drained sandy loam soils. Seeds are sown in rows 60 cm apart using a seed rate of 5-7 kg/ha.
- When the seedlings are nearly 3 cm high, thinning is done to maintain a plant to plant distance of 7-10 cm.
- The plants flower in 5 months and bear seeds a month later.

Limitations and Researchable Issues

1. Difficulty is encountered at harvesting as ripening is not uniform and nutlets (seeds) are shed shortly after ripening. Therefore, there is a need to develop high yielding varieties uniform in maturity and resistance to shattering.

6.2 SIMAROUBA (*Simarouba glauca* DC)

Simarouba glauca DC, commonly known as paradise tree, king of oil trees, aceituno and simarouba, belongs to family Simaroubaceae. It is an evergreen tree growing up to 15 metres height. It has a tap root system with cylindrical stem. The alternate imparipinnate compound leaves have 13-23 leaflets. The plants are polygamodioecious with a male to female ratio of 3:2. About 5% of the population produces exclusively staminate (male) flowers, 40-50% produces mainly male

flowers with a few bisexual flowers (andromonoecious) and the remaining 40-50% produces only the pistilate (female) flowers. Inflorescence is a panicle with ultimate branches ending in dischasial cymes. Flowering begins in December and continues up to following February. The trees start bearing when they are 4-6 years old (Grafts begin to do so in 3-4years) and reach stability in production after another 4-5 years .The fruits, drupelets (blackish purple in pink genotypes and brownish yellow in green genotypes) are ready for harvest by April/ May.

Distribution and Adaptation

Simarouba is a native of El Salvador, Brazil and was introduced in India during 1966 at NBPGR Regional station Amaravati (Maharastra). It grows well in tropical and sub tropical conditions. It can be grown throughout the plains up to altitude of 1000 masl. It is suitable for cultivation under rainfed conditions with an annual rain fall of 500-2200 mm. It grows well in all types of soils with pH 5.5-8.0 except coastal sandy and clay soils. A large area (> 2000 ha) of wastelands in Orissa has been planted by this tree. Tamil Nadu and AP states are also bringing a large area of waste lands under this tree. As this tree gives a very good look, it is also being planted along the road sides as road avenue.

Uses

- All parts of simarouba are useful in one way or the other. However, in the present context the seeds are economically very important as they contain 60-75% edible oil which can be used in the manufacture of vegetable fat and /or margarine.
- From 1950 onwards, in El Salvador and other Central American countries the Oil is marketed for edible purposes under the trade name of Manteca Vegetal "Nieve" and the oil is well accepted.
- As industrial oil, it is well suited for the manufacture of quality soaps, lubricants paints, polishes and pharmaceuticals.
- The oilcake being rich in nitrogen (7.7-8.1%), phosphorus (1.1%) and potash (1.24%) serves as a valuable organic manure.
- The shells (endocarp) can be used in hard - board industry. They can also be pulverized and added to enrich the compost since they contain about 1.2% potash.
- Pulp, about 20 kg/tree /year, constituting about 60% of the fresh fruitlet by weight, contains about 11% sugars and can be used for beverage manufacture or in fermentation industry.
- Leaf liter (about 20 kg tree/year) makes a good manure, improving the fertility status of the soil.
- The leaf and bark contain simarubin, a chemical useful in curing amoebiasis, diarrhea and malaria .

- Wood is light and generally insect resistant , hence useful in making light furniture, toys, packing material , pulp (for paper industry) and matches. It makes a good fuel too.

- This ecofriendly tree is well suited for wasteland reclamation and is ideal for watershed areas.

Varities/ Planting Material

The useful material selected at FCRI , Mettupalaym (TN), the AICRN (UUC) center, is available for sale in the form of seeds as well as seedlings.

Cultivation Practices

- Simarouba seedlings are raised during April- June in Poly bags (15x25 cm) filled with nursery mixture. Seedlings from the mother bed are picked at 2-3 leaf stage to transplant in poly bags. Three to six month old seedlings are ready for transplanting in pits of the field at the recommended spacing of 6x 6 m (277 trees /ha). After 3-4 years when the male plants come in flowering their stems are cut for in situ grafting of female scion on the new shoots to keep female : male ratio of 6 : 1.

- Alternatively , the soft –wood cleft grafts of elite lines with known sex are preferred for planting the male and female trees in the desired ratio of 1:6 to get higher and earlier returns. This cleft grafting with the known sex can be done in poly bags when the seedlings have been transferred from the mother bed.

- The epicotyl grafting from the known sex can also be attempted in poly bags in 25 day old seedlings

- Even though, the tree starts bearing fruits in the 3rd or 4th year but economic yield (20 kg seed /tree) is achieved in 10th year onwards.

6.3 TUMBA [*Citrullus colocynthis* (L.) Schrad.]

Tumba, known as bitter apple, wild gourd, indrayan, colocynth and vine of Sodom, is a close relative to watermelon (*Citrullus lanatus* ; 2n=22) belonging to Cucurbitaceae family. It is a trailing / spreading herb of deserts and semi deserts with long tap perennial root system having soil binding capacity particularly in sand dunes. Stem is prostrate, angular, slender, branched and hirsute when young. Tendrils are usually simple, slender, short, scabrid-hirsute below, almost glabrous above, the lower straight portion persistent, at length becoming almost sinous. Leaves are alternate, spiral, simple, petiolate, 3-6 x 2.5 cm in size, deeply 3-lobed, middle lobe the largest, pale green above, ashy beneath. Lower surface in young leaves is densely hirsute. Flowers are monoecious, solitary, peduncled, axillary, corollas 5-lobed; ovary villous. Fruit a pepo, nearly globular, 4-10 cm in diameter with somewhat elliptical fissures, about the size of a small orange, green and yellow variegated becoming yellow when ripe, with hard rind, pulp light in weight, spongy, easily broken, light yellowish-orange to pale yellow, intensely bitter. Seeds numerous, ovoid, compressed, smooth, dark brown to light yellowish orange, borne on parietal placenta.

Distribution and Adaptation

Native to dry areas of North Africa, it is common throughout Sahara, areas of Morocco, Egypt and Sudan, eastward through Iran to India and other parts of tropical Asia. It has been known since Biblical times and cultivated in the Mediterranean region, especially in Cyprus and in India for many centuries. Ranging from cool temperate moist through tropical desert to Wet Forest Life Zones, colocynth is reported to tolerate annual precipitation of 38 to 429 mm, annual temperature of 14.8 to 27.8°C and pH of 5.0 to 7.8. A highly xerophyte, it thrives well in sandy loam, sub desert soils and along sandy sea coasts. In India it is estimated to be grown in about 1.5 m ha mostly in wild form, sporadically in cultivators' fields, waste lands, fallow marginal and sub marginal tracts giving on an estimate produce of about 2.24 million qt seed, of which > 50 % is fed to cattle and rest arriving at milling units.

Uses

- Major use of tumba is in stabilizing shifting sand dunes.
- Apart from being a good soil binder, tumba has medicinal values also. Because of having glucosides such as colocynthin, the dried pulp of unripe fruit is used as drastic hydragogue and laxative/purgative. The fruits have been commonly used as catharsis and antidiabetic agents. There are several reports from different parts of the world where different parts of this plant have been reported to be used for treatments of various diseases like amenorrhea, ascites, bilious disorders, cancer, fever, jaundice, leukemia, rheumatism, snakebite, tumors (especially of the abdomen) and urogenital disorders.
- The seed contains 19-21 % oil which is used for manufacturing soap, candles etc.
- The fruits are used as feed for cattle, goats and camels.

- In famine and scarcity, tumba seeds are mixed with bajra grains, floured and eaten by poor people (Chaudhary and Solanki 2008).

Variety

Mansha Marudhara (RMT 59) : The variety released in 2004 was developed at ARS, Mandor (Jodhpur) of Rajasthan Agricultural University Bikaner. The variety was developed by mass selection from local collection GP 59. The variety is released for marginal soils and wastelands including sand dunes in states of Gujarat and Rajasthan for rainfed farming. The average seed yield is 2.38 q/ha with fresh fruit yield of 51 q/ha. Oil content in seeds is 43%, and protein content in defatted cake is 43%. It is drought tolerant and can survive well in hungry & thirsty soils under marginal and sub marginal conditions including wastelands & sand dunes after its one year of establishment.

Cultivation Practices

- On wastelands it is sown as pure crop, whereas on marginal lands it is mixed with pearl millet during onset of monsoon season. As a pure crop it can be sown either directly or raising nursery at a spacing of 6m x 1m.
- Since there is a problem in seed germination, at least two seeds should be placed at one point at 2.5 cm depth. For one hectare, about 500g seeds should be kept in a water soaked moist gunny bag for about 3-4 days (the bag can even be buried in soil at about 18" deep pit and kept watering the pit). The seeds are then to be rubbed before sowing in the field. Alternatively, 250g seeds can be germinated in 20x15 cm poly bags, filled with sand, soil and FYM in equal proportion, and keeping these bags in a nursery under shade and moist conditions.
- The germinated seeds (seedlings) can be transplanted in field either during rainy day or apply irrigation after transplanting.
- In mixed cropping the row to row distance can be kept at 15 m so that the predominant crops like pearl millet, moth bean, sesame or cluster bean can be properly cultivated every year between two rows of tumba.
- In the 1st year, tumba gives low yields but its yield increases year after year. Picking of fruits is done when they are ripe and yellow in color, usually in the month of December.
- Following fungi are known to attack colocynth: *Colletotrichum bryoniae, Erysiphe cichoracearum, E. polyphaga, E. semitectum, Fusarium oxysporum,* and *Puccinis citrulli.* The Bottle gourd mosaic virus and the nematode, *Meloidogyne* sp. are also reported to attack this plant.

Researchable Issue

Seed germination is a major problem because of its thick seed coat. The thickness is required to be reduced by crossing with *C. lanatus* varieties.

6.4 JATROPHA (*Jatropha curcas*)

Jatropha is a morphologically diverse genus comprising 176 species of shrubs, rhizomatous and herbs. Among them, 13 species are recorded in India. *Jatropha curcus,* the physic nut or the purging nut, known by about 200 vernacular names such as Kattamanakku in Tamil, Ratanjyot / safed arand in Hindi, is closely related to castor and belongs to family Euphorbiaceae. Finding a renewable alternative to conventional High Speed Diesel (HSD) is an idea that dates back to 1930s. A more resilient source has been found in *Jatropha curcus*, an oil bearing, drought hardy shrub. It is a diploid species with 2n=22. It is a drought-resistant perennial crop growing well in marginal/ poor soils. The shrub is easy to establish, grows quickly and may survive for several years producing seeds. Plant looks like a soft wooded shrub or a tree of 3-5 m height having 3-5 lobed pale green leaves with 10-15 cm long petiole and is deciduous. The leaves, generally, fall off after winter season when the fruiting is over. The plant is monoecious with a high ratio of male: female flowers, generally crossing 10:1. Staminate and pistillate flowers open on different days in the same inflorescence. This promotes cross pollination which is mainly through insects. The inflorescences are formed terminally or axillary in bunches / sub bunches, having female flowers with slightly larger and thicker pedicel. Each sub bunch has 3-7 female flowers, interspersed with several male flowers. In the androecium, ten stamens are arranged in two alternate whorls of five each. The filaments are fused in to a column. The gynoecium has three slender styles with tricarpellary, syncarpous, superior and trilocular ovary. The seeds resemble

castor seeds in shape and are ovoid, oblong and black in color. The seeds become mature when the capsule changes from green to yellow after 2- 3 months of fertilization. The seeds can germinate just a week after the harvest.

Jatropha can have continuous flowering and fruiting under irrigated conditions with normal soil temperature. In Tamil Nadu flowering and fruiting occurs through out the year under irrigated conditions, but in North India it usually occurs during July to January with its peak period between August and September.

Distribution and Adaptation

Its centre of origin is still uncertain, but it is believed to be Mexico and Central America. It has been introduced to Africa and Asia and is cultivated world-wide. In India introduced about 400 years back has spread to almost all parts including Andaman & Nicobar. This highly drought-resistant species is adapted to arid and semi-arid conditions. The current distribution shows that introduction has been most successful in the drier regions of the tropics with annual rainfall of 300-1000 mm. It occurs mainly at lower altitudes (0-500 m) in areas with average annual temperature well above 20°C but can grow even at higher altitudes. It grows on well-drained soils with good aeration and is well adapted to marginal soils with low nutrient content. It is found to be growing in many parts of the country, rugged in nature and can survive with minimum inputs. In India, several states particularly Tamil Nadu, Chhatisgarh, AP, Gujarat, Rajasthan and Orissa have planted Jatropha on thousands of hectares of waste lands to promote its cultivation as a bio fuel. Depending on soil quality and rainfall, oil can be extracted from the nuts after two to three years. With good maintenance, there can be fruit set even in the same year of plantation.

Uses:

- Jatropha has been reported to be useful in several ways (Paramathma et al. 2006).
- This wonder plant, produces seeds with an oil content of 37%. The crude oil can be combusted as a fuel. However, the trans-esterified oil can be used as biodiesel or paraffin substitute or extender.
- Its by-product, the press cake, is a good source of organic fertilizer. The oil has insecticidal properties also.
- Jatropha is being used in traditional medicines for curing many diseases like cancer, piles, snakebite, paralysis, dropsy etc.
- The cut branches sprout and grow readily making it most suitable for fencing.

Variety

Chhatrapati (SDAUJ-1) : The variety released in 2006 for states of Gujarat, Orissa, Haryana and Maharastra was developed at SDAU Sardar Krushinagar by the selection

of the material collected from Maharastra state. The variety, on an average, gave seed yield of 3.60 q/ha up to 4th year of plantation. Its seed kernels have 49.2 % oil (32.1 % in seeds) which was highest among all the tested entries The protein in defatted seed cake(non- edible) is 47.8(%). In general, it is resistant to major diseases. However, the incidence of root rot may occur when the soil temperature fluctuates. This disease can be effectively controlled by drenching with 1% bordeux mixture. It is resistant to lodging by virtue of its being either shrub or a small tree. It is perennial and the flowering may come either in the same year or in the 2nd year. The main flush comes in the months of November-December. Its 100 seed weight is about 45 g. The leaves are light green but the terminal leaves show brownish red colour.

Cultivation Practices

- It propagates easily either through seeds or seedlings or cuttings. Well developed plumpy seeds are selected for sowing.
- Before sowing, seeds are soaked in cow dung solution for 12 hrs and kept under wet gunny bags for 12 hrs. 1-2 germinated seeds are grown in poly bags of 10x20cm size filled with soil, sand and FYM in equal proportion. Three month old seedlings can be transplanted in rainy season at a spacing of either 2m x 2m or 3m x 3m. The 3m x 3 m spacing provides a good scope of taking an intercrop and easy intercultural operations. However, the plantations can be done in SAUCER method also where the planting is done in a circle of 1 m radius adjusting about 4 plants in the circle and the central portion is left for water accumulation.
- When planted through cuttings, the terminal cuttings of 20-25 mm diameter are most suitable for better rooting and sprouting.
- To manage the shrub and having good branching every year, pruning can be done depending upon the condition of the shrub. In the 1st year, pruning can be done at about 30 cm from the ground level at about 9-10 months of age (March /April). Thereafter, in the subsequent period the top 1/3rd of each branch can be pruned to stimulate secondary branching when the plant is at dormant stage.
- Being a perennial crop, any short duration inter crop suited to the local area can be adjusted between two rows during the first two years or when the crop is not in full bloom. Crops like bitter gourd, pumpkin, black gram, cucumber, senna, karingada and moth bean have been tried at different centres. Some of these creepers can serve as a good mulch and conserve moisture for Jatropha.
- Application of N:P:K at the rate of 45:30:0 kg / ha every year has been found to give good response for getting good seed yield and shelling (%).

Limitations and Researchable Issues

1. A very low variability exists with respect to yield and its contributing traits among the collections made from different parts of the country. Therefore, there is a

need to create additional variability for its further improvement in yield to make its cultivation an economical entrepreneur.

2. The plantations under irrigated conditions at some stage become very sensitive to diseases particularly the root rot. Therefore, either the resistant materials are required to be developed or control measures are to be standardized.

3. The available plant types are indeterminate and there is very low percentage of fruit set from the available female flowers. Therefore, an ideal plant type is required to be structured for economical yields.

4. There is non synchronous maturity of the inflorescence and fruits fall on the ground. This creates problem in the pickings. Therefore, plant types with synchronous maturity are required to be developed.

6.5 JOJOBA (*Simmondsia chinensis*)

Jojoba (*Simmondsia chinensis*), pronounced as " HOHOBA" is an evergreen shrub, native to triangle of Sonoran and Mojave deserts of Arizona, California and Mexico. It is the sole species of the family Simmondsiaceae and is sometimes placed in the box family Buxaceae. It is also known as goat nut, deer nut, pignut, wild hazel, quinine nut, coffee berry and gray box bush.

The shrub is 3-5 m tall with broad and dense crown. The leaves are opposite, oval in shape, 2-4 cm long, 1.5-3 cm broad and thick waxy glaucous gray-green in color. The flowers are small, greenish-yellow having 5-6 sepals but no petals. Jojoba plant is dioecious with hermaphrodites being extremely rare. The fruit is an acorn-shaped ovoid,

three-angled capsule 1-2 cm long, partly enclosed at the base by the sepals. The mature seed is a hard oval, dark brown in color and contains an oil content (liquid wax) of approximately 54%. An average-size bush produces a kilogram of pollen, to which few humans are allergic.

Jojoba foliage provides year-round food opportunity for many animals, including deer, javelina, bighorn sheep, and livestock. The nuts are eaten by squirrels, rabbits, other rodents and larger birds. In large quantities, the seed meal is toxic to many mammals, and the indigestible wax acts as a laxative in humans.

Distribution and Adaptation

Because of sperm whales being endangered, plantations of jojoba have been established in a number of desert and semi-desert areas, predominantly in Argentina, Australia, Brazil, Israel, Mexico, Palestine, Peru, USA, Western Asian and African countries. To promote its cultivation in wasteland of India and particularly in states of Rajasthan, Gujarat and Orissa, a society named Association of Rajasthan Jojoba Plantation & Research Project (AJORP) was set up in 1994 with the financial assistance of Department of Land Resources, Ministry of Rural Development, Govt. of India. This Association has established several model farms, each farm with 50-100 hactare area, in states of Gujarat and Rajasthan.

Uses

- Jojoba is grown for the liquid wax (commonly called jojoba oil) in its seeds. This oil is more similar to Sebum and Sperm Whale oil than to traditional vegetable oils. Jojoba oil is easily refined to be odorless, colorless and oxidatively stable oil which is chiefly used as a substitute of sperm whale oil as lubricant in high pressure machinery. It is also used in cosmetics as a moisturizer and as a carrier oil for specialty fragrances.
- It has a potential to be used as a biodiesel fuel for cars and trucks as well as a biodegradable lubricant.
- Other potential use of the oil is as a component of hair oil, shampoo, soap, face creams and pharmaceuticals.

Variety

EC 33198: It gives higher seed yield and is tolerant to drought. It was recommended for release in 1986 for arid regions and coastal areas. Average seed yield in normal condition is 5.0 q/ha (5-7 years old). The seeds of this variety are available with NBPGR Regional Station, CAZRI, Jodhpur (Rajasthan)

Cultivation Practices

- The plants can be raised either using seeds or seedlings or rooted cuttings or the tissue cultured plantlets. The plants raised through seeds are weak and therefore,

planting through seedlings is preferred. However, the best method of propagation is through cuttings as this has a pre-knowledge of shape and the sex of the plants.

- The recommended row to row and plant to plant distance is 4m and 1m respectively. However, row to row distance can be kept as 4.5 m for mechanized farm operations and plant to plant distance at 2m in case of cuttings.
- The sowings in the field or the nursery raising in 23x10 cm poly bags filled with nursery mixture can be done either in October or March. To protect the seeds from seed borne diseases, the seeds should be soaked in water for 8-10 hrs, then treated with 0.2 % solution of Bavistin (2g/litreof water) for 3-5 minutes and then used for sowing after drying the seeds.
- 4-5 month old seedlings can be transplanted in the field. In nature the male : female ratio is 50:50 and therefore, when planted through seedlings, two seedlings are kept at one place (spaced at 6") and rouging is done in male and female rows to keep the desired ratio of 1:10.
- The direction of rows should be from North to South, opposite to wind direction, for proper pollination.
- The fertilizer doze of N:P:K should be 75 : 37.5 : 75 kg/ha in the 1st year and it should be enhanced by 15 : 7.5 : 15 kg/ha every year over the preceding year. If annual rainfall is below 640 mm, supplementary irrigation is required to ensure economic yields.
- In poorly drained soils, Jojoba is affected by fungal pathogens like Verticillium, Fusarium, Pythium, Phytophthora etc. Accordingly control measures are required to be undertaken to save the crop. Major insect affecting this crop is termite. It is recommended to apply Endosulphan Dust (4%) @ 25 kg/ha at the time of ploughing the field. In the standing crop, 4-5 litres of Endosulphan (35EC) or Chloropyriphos (20EC) can be applied.
- To give an umbrella shape to the shrub pruning can be done from 2nd year onward by leaving 0.5 m single stem from the ground level.
- In the initial years, low height crops such as green gram, moth bean, ground nut, chickpea, cucurbits etc can be taken as inter crops to get economic benefits.

Limitations and Researchable Issues

1. As the plant is dioecious , it is difficult to maintain the desired male female ratio at the time of planting. Some techniques are required to be developed to identify the sex at early plant stage.
2. More genetic material is required to be evaluated for higher yields.

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INDUSTRIAL CROP 7

Only one introduced crop namely guayule was evaluated in this group. The crop is an excellent source of allergy free rubber.

7.1 GUAYULE (*Parthenium argentatum* Gray)

Guayule (*Parthenium argentatum*), pronounced 'why-YOU-lee', is a shrub in the genus *Parthenium* of the family Asteraceae. It is native to the south western United States and northern Mexico, grown in the states of Texas, Zacatecas, Coahuila, Chihuahua San Luis Potosi, Nuevo Leon and Tamaulipas. The plant is used as an alternate source of latex which is hypoallergenic, unlike the normal *Hevea* rubber. In pre-Columbian times, the guayule was a secondary source of latex for rubber, the principal source being *Castilla elastica* tree. The name "guayule" derives from the Nahuatl word *ulli/olli*, "rubber".

Adaptation and Distribution

For sustainable production, guayule grows well in arid and semi arid areas of the southwestern United States, North Central Mexico and the other regions with similar climates around the world. Because guayule plant produces terpene resins, the natural pesticides, it is resistant to many pests and diseases.

Uses

- Guayule plant has seen a small but growing resurgence in research and agriculture for its rubber production due to its hypoallergenic properties. While Hevea-derived rubber contains proteins that can cause severe allergic reactions in a few people, guayule does not. There are synthetic alternatives for medical device products, but they are just not as stretchy as natural rubber. Guayule performs like Hevea but contains none of the proteins that cause latex allergies.
- The company leading the commercialization of guayule as an industrial crop is Yulex Corporation, manufacturing and producing medical devices and specialty consumer products that are safe for people who have latex allergy. Yulex's biorefinery extracts biomass into economic renewable, bio-based materials such

as cellulosic ethanol, adhesives, organic pesticides, wood preservatives and other specialty chemicals.

Varieties

Arizona-1 : The selection from introduced material was identified for cultivation in 1986 for arid and semi-arid areas of India. It has average yield potential of 13.50 q/ha. It is drought tolerant and has medium vigour. The rubber content is about 6%.

HG-8 : The variety identified in 1990 was developed at CCS HAU, Hissar through selection in an introduction from Arizona. It was identified for commercial exploitation as an additional source of rubber in the arid and semi arid zones of the country. The variety is an alternative source of *Hevea* rubber. It gives rubber in $2\text{-}2^{1/2}$ years in comparison to 7-8 years in *Hevea*. Guayule rubber has a wide acceptability for industrial uses. It has the potential to be grown successfully on wastelands and degraded lands. It has distinguishing morphological characters with high vigour, profuse branching, tall and thick stem with excellent canopy. It has better germination and survival percentage as compared to other varieties. The plant attains an height of about 100-120 cm with main stem girth of 15-20 cm and canopy circumference of 300-350 cm. Plant bears 15-20 tillers with an average yield of 1.5-2.0 kg fresh shrub and 0.75 g - 1.0 kg dry shrub. The fresh root weight varies from 600 - 750 g and dry root weight 250 - 300 g. The variety matures in 2 - 2.5 years and gives an average rubber yield of 15.00 q/ha on basis of 6.7% rubber content in the stem under Hisar (Haryana) conditions. It has resin to the extent of 4-5 %. The variety is tolerant to root rot and free from insect- pest incidence.

Cultivation Practices

- The crop is perennial and suited to arid and semi arid areas of the country. Normally, it is recommended for poor soils under rainfed dry conditions.
- Sowing at a spacing of 60 x 60 cm can be done with onset of monsoon. A fertilizer dose of N : P @ 40 : 30 kg /ha in Ist Year and 20 kg N in 2^{nd} year is recommended.
- The field should be free from weeds for better establishment.
- Generally, 1-2 light irrigations are required during summer. The crop is ready to harvest at about 2-3 years age. Flowering occurs in the month of March- April and seed sets in the month of June. Rubber content in stem and branches is maximum just before the flowering and therefore, harvesting should be done in the month of February.
- Self incompatibility has been reported in Guayule species. So the seed production should be carried out while keeping an isolation distance of 200 meters.

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Annexure I

Some important underutilized - neglected crops and minor plant species in Asia-Pacific region

S.No.	Category	Crops/ Species
1	Pseudo cereals	*Amaranthus* spp. *Chenopodium* spp. Buckwheat *Fagopyrum esculentum, F. tataricum*
2	Small Millets	*Digitaria* spp. *Echinochloa* spp., finger miller (*Eleusine coracana*), proso millet (*Panicum miliaceum*), pearl millet (*Pennisetum americanum*), little millet (*Panicum sumatrense*), kodo millet (*Paspalum scrobiculatum*), foxtail millet (*Setaria italica*); others – *Brachiaria* spp., *Coix lachryma-jobi*
3	Pulses	Sword bean (*Canavalia* spp.), hyacinth bean (*Lablab purpureus*), grasspea (*Lathyrus sativus*), horse gram (*Macrotyloma uniflorum*), velvet bean (*Macuna* spp.), winged bean (*Psophacurpus tetragonolobus*), faba bean (*Vicia faba*), moth bean (*Vigna aconitifolia*), adzuki bean (*Vigna angularis*), rice bean (*Vigna umbellata*), others – *pilipasara, Vigna trilobata, Parkia roxburghii* (multipurpose)
4	Roots and Tubers	Elephant foot yam (*Amorphophallus paeoniifolius*), taro (*Colocasia esculenta*), yams (*Dioscorea* spp.), *Vigna vexillata*
5	Vegetables	Cucurbitaceae (*Benincasa, Lurffa, Momordica Trichosanthes* spp.), aibika (*Abelmoschus manihot*), leafy amaranth (*Amaranthus* spp.,), *Brassica* spp., Kangkong (Ipomoea *aquatica*)
6	Fruits and Nuts	Jackfruit (*Artocarpus heterophyllus*), breadfruit (*A. allitis*), carambola (*Averrhoa carambola*), longan (*Dimocarpus longan*), pilinut (*Canarium ovatum*), durio (*Durian zibethinus*), Indian gooseberry (*Emblica officinalis*), mangosteen (*Garcinia mangostena*), duku (*Lansium domesticum*), litchi (*Litchi chinensis*), *Manikara* spp. Rambutan (*Nephelium lappaceum*), pistachio (*Pistachia vera*), jamun (*Syzygium cumini*), tamarind (*Tamarindus indica*), Indian jujube/ber (*Ziziphus mauritiana*), Chinese jujube (*Ziziphus jujube*)

S.No.	Category	Crops/ Species
7	Oil Plants	Safflower (*Carthamus tinctorius*), colocynth (*Citrullus colocynthis),* niger (*Guizotia abyssinica*), physic nut (*Jatropha curcas),* Sesame (*Sesamum indicum)*
8	Fibres and Pulp	Ramie (*Boehmeria nivea*), sunn hemp (*Crotalaria juncea*), kenaf (*Hibiscus cannabinus*), flax (*Linum usitatissimum*, dhainha *(Sesbania bispinosa*)
9	Others	Sago palm (*Metroxylon sago*), bamboo

Varieties Released Through All India Coordinated Research Network on Underutilized Crops

Crop	Variety	Year of identification/ release./	Economic product	Average yield (q/ha)	Characteristics	Recommended areas
GRAIN AMARANTH						
1	Annapurna	1984	Grain	22.50	High yield potential, high protein (15%) drought tolerant and wider adaptability	Mid and high Himalayan region of India
2	GA-1	1991	Grain	19.50	High seed yield and drought resistant	Gujarat, Maharashtra
3	Suvarna	1992	Grain	16.00	Drought tolerant, high yield	Peninsular region (Karnataka, Orissa) Gujarat
4	PRA-1 (PRA 8801)	1997	Grain	14.50	High grain yield	Uttaranchal hills
5	PRA-2 (PRA 9101)	2001	Grain	14.50	High grain yield	North-West Himalayan region except J&K
6	GA-2	2002	Grain	15.50	High grain yield	Gujarat state
7	PRA-3 (PRA 9401)	2003	Grain	16.50	High grain yield	North-West Himalayan region except J&K
8	IC 35407 (Durga)	2006	Grain	21.00	High grain yield and Early maturing	North west hill zone comprising states of Himachal Pradesh Uttaranchal and J &K
9	BGA-2 (Kapilasa)	2006	Grain	13.26	High grain yield and Early maturing	Karnataka, Orissa and Tamil Nadu

10	VL Chua 44	2006	Grain	13.20	Early maturing (110-120 days), escapes from Leaf webber and has non spiny bract for easy threshability	Mid and higher hills of Uttaranchal
11	GA-3	2008	Grain	12.58	High grain yield	States of Gujarat and Jharkhand
12	RMA- 4	2008	Grain	13.90	High grain yield	States of Rajasthan, Jharkhand and Orissa
BUCKWHEAT						
13	Himpriya	1991	Grain	12.00	High grain yield, medim maturing F. tataricum	High altitude areas of Himachal Pradesh and Uttrakhand
14	VL Ugal 7	1991	Grain	8.00	Early maturing, moderate yield F. esculentum	Mid hills of Uttrakhand
15	PRB 9001 (PRB 1)	1998	Grain	12.00	High yielding F. esculentum, medium maturity	Hill region of UP, HP and North Easten states
16	Himgiri (Shimla B-1)	2006	Grain	11.12	Early maturing (81-95 days)	Dry temperate region of Himachal Pradesh and J & K
17	Sangla B-1	2006	Grain	12.65	Medium in maturity(104-108 days) and high yielding	Mid and high hills of Himachal Pradesh and Uttranchal
WINGED BEAN						
18	AKWB-1	1991	Green pods	105.00	Dual purpose (seed and vegetable), high pod yield	All winged bean growing areas
FABA BEAN						
19	VH 82-1	1998	Grain	14.55	High seed yield, medium maturity	Northern plains

RICE BEAN						
20	RBL-1	1986	Grain	16.00	High yielding, medium maturing, light green seeded, resistant to diseases and stored grain pests	Punjab
21	PRR-1	1995	Grain	15.00	High yielding	Uttaranchal hills
22	PRR-2	1997	Grain	12.00	High seed yield, shining light yellow seed	Hill region of UP, HP, and North Easten states, particularly mid and high altitudes
23	RBL-6	2000	Grain	13.33	High yielding, medium in maturity, light green seeded, resistant to diseases and pests	Entire plain Zone
24	RBL 35	2003	Grain	11.65	Early maturing	Plains
25	RBL 50	2003	Grain	10.90	Dark green seeds	Plains
26	BRS 1 (Identified)	2003	Grain	14.50	Early maturing and high seed yield	Hills
KALINGADA						
27	Gujarat Karingada -1	2001	Seed and vegetable	10.00	High protein (18%), oil (37.1%) and TSS (3.4%)	Arid/semi arid areas of Gujarat
GUAYULE						
28	Arizona-1	1986	Rubber	13.50	Drought resistant, high rubber content (6%), medium vigour	Arid and semi arid areas
29	HG-8	1991	Rubber	15.00	High rubber content (7%), tolerant to root rot, vigorus growth	Arid and semi arid areas
TUMBA						
30	RMT 59	2005	Seed/oil	2.38	High fruit and	Rajasthan and

	(Mansha Marudhara)				seed yield	Gujarat
JOJOBA						
31	EC-33198	1986	Oil	5.00	High seed yield, drought tolerant	Arid regions and coastal areas
KANKODA						
32	Indira Kankoda (RMF-37)	2007	Vegetable	15-20	High fruit yield	Chhatisgarh, Uttar Pradesh, Jharkhand, Orissa and Maharashtra
JATROPHA						
33	Chhatra-pati (SDAUJ-1)	2006	Oil	4.00 (3rd year)	High yield and oil percent	Gujarat and Rajasthan under rainfed conditions