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Major **Cereals**, Pulses, Oilseed, Fodder, cash , vegetable and horticulture crops (*Kharif Seson*)

RICE Oryza sativa (2n=24) Rice is one of the oldest cultivated crops. The two cultivated species of rice are i) Oryza sativa - Asian rice ii) O. glaberrima - African rice. The three races in cultivated Asian rice are i) indica ii) Japonica (Sinica) iii) Javanica. Origin of cultivated rice. The views regarding the origin of rice can be grouped in to two classes viz., a) Polyphyletic origin b) Monophyletic origin. i.Polyphyletic: Originated from several species. According to this theory, the two forms of cultivated rice viz., Asian rice O.sativa and African rice O.glaberrima have evolved independently in their respective regions from several species. Common ancestor South & South East Asia Tropical Africa Perennial O.rufipogon O.longistaminata Annual O.nivara Weedy annual O.barthii O.spontanea O.sativa O.Staffii O.glaberrima indica japonica javanica ii. Monophyletic : According to this theory both Asian rice and African rice arose from a common parent (O.perennis). This view is the most accepted one because both Asian rice and African rice are similar except in glume pubescence, ligule size and colour of pericarp which is red in African rice. O.perennis O.glaberrima O.sativa According to polyphyletic origin the present day rice varieties have originated from several species. According to monophyletic origin a single species has given rise to all varieties of cultivated rice. Viz., Oryza sativa Oryza glaberrima 3 most of the modern rice workers believe that origin of cultivated rice monophyletic. From oryza perennis rose the Asian rice in South East tropical Asia and African rice in the upper valley of Niger River in Africa. Species in the genus oryza: According to the latest view the genus oryza include 20 wild species. Out of these two are cultivated diploids viz. O.sativa and O.glaberrima and rest are wild species which include both diploid and tetraploid forms. Botanical name Chromosome No. Genome Origin O.sativa 24 AA Asia O.nivara 24 AA Asia O.meridionalis 24 - Australia O.longistaminata 24 AA Africa O.rufipogan 24 AA Asia O.glumaepatula 24 - America O. grandiglumis 48 CCDD America O.glaberrima 24 AA Africa O.barthii 24 AA Africa O.australiensis 24 EE Australia O.latifolia 48 CCDD America O.alata 48 CCDD America O.eichingeri 24 CC Africa 48 BBCC O.minuta 48 BBCC Asia O.punctata 48 BBCC Asia O.officinalis 24 CC Asia O.granulata 24 - Asia O.meyeriane 24 - Asia O.ridleyi 48 - Asian O.longiglumis 48 - New Guninea O.brachantha 24 FF Africa O.schlechter - - New Guinea 4 RICE Related species of rice and their contributing characters in rice improvement. Species Genome Useful traits O.alata CCDD High biomass production O.australiensis EE Drought tolerance, BPH resistance O.barthii AA Drought avoidance, BLB resistance O.brachyantha FF Yellow stem borer and leaf folder resistance O.eichengeri CC BPH, GLH, WBPH resistance O.grandi glumis CCDD High biomass production O.granulata unknown Shade tolerance, adaptation to acrobic soils O.latifolia CCDD High biomass production O.longistaminata AA Drought tolerance O.meridionalies AA Elongationability O.meyeriana Unknown Shade tolerance, adaptation to aerobic soils O.minuta BBCC BPH, GLH, WBPH, BLB and blast resistance O.nivara AA Grassy stunt virus resistance O.officinatis CC,BB,CC BPH, GLH, WBPH resistance BPH resistance O.prnetate BB, BBCC BPH resistance O.ridleyi unknown Shade tolerance, stemborer, blast and BLB resistance O.rufipogon AA Source of CMS 5 Wild Species: There are twenty valid species in the genus oryza of these two are cultivated i.e. Oryza sativa Oryza glaberrima In the remaining 18 species nine are diploid ones. Six - tetraploid ones Two - mixed diploid One - chromosome number not reported. Some of the wild species utilised in breeding programme are Oryza perennis - Co 31 GEB 24 x O. perennis Oryza nivara - IR 34 One of the parents is O.nivara resistant to grassy stunt disease. BREEDING OBJECTIVES 1. High yield potential 2. Adaptability and stability of yield 3. Early maturity. 4. Resistance to lodging and shattering 5. Resistant to cold temperature. 6. Resistant to salinity and alkalinity 7. Resistant to diseases. 8. Resistant to pests 9. Improved grain quality a) Grain shape and size b) Texture of Endosperm and quality of starch in Endosperm c) Aroma & Cooking quality d) Colour of kernel f) Milling out turn 10. Breeding for alternate source of dwarfing gene. 11. Breeding varieties suited for direct seeding 12. Breeding varieties for dry lands 13. Breeding varieties for deep water conditions 14. Breeding varieties for export - scented rice 15. Breeding varieties to control wild rice 16. Breeding varieties to suit any other local conditions. 1. High

yield potential Grain yield of rice is a complex character. It is influenced by many morphological traits and physiological process. These along with interaction of environment decide the yield potential. It is necessary to assemble in the rice variety a desirable combination of genes for those plant characteristics, that will enable the rice plant to give higher yields. To get higher yield we must have an ideal plant type. The ideal plant type is - Short stature. - Thick, Stiff culm - Compact panicle that hold the plant erect. - Short, narrow, erect leaves to effectively utilise solar radiation. - high tillering 6 - Non / low photo sensitivity - Nitrogen responsive - Flag leaf angle should not be more than 400 . 2. Adaptability and stability of yield : Wide adaptability across locations is desired since rice is grown over a large variety of agroclimatic zones which are varying. IRR1 varieties are having wide adaptability. Characteristics associated with wider adaptability are - low sensitivity to temperature variations. - low sensitivity to changes in light intensity. - Resistant to wide spectrum of pests and diseases. Across seasons refers to the consistency with which a variety produces satisfactory yield in an area where biotic and abiotic conditions may vary every season of a year. Tolerance to local fluctuations in biotic and abiotic stress is important. 3. Early maturity: This character is desired to have multiple cropping. It is also helpful to overcome terminal drought and to escape from pest and diseases. In rice the optimum early maturity will be around 105 days. When the duration is reduced still further, the yield is also reduced correspondingly. CR 666, Akashi, Co 41 are varieties having less than 100 days duration. 4. Resistant to lodging and shattering. This is also a complex character. Non lodging lines will have - Short stature - Thick strong culm - Short internode - Leaf sheath tightly encircling the culm. Grain shattering is also a complex character. Wild rices are having this character. So while using wild rice as parents this should not be linked with desirable trait which is to be transmitted. 5. Resistance to cold temperature More suited to cumbum valley and Gudalur taluk of Nilgiris. Japonica rice varieties are more cold tolerant MDU 2 cold tolerant (Co 25 x IR 8) 6. Resistant to salinity and alkalinity : Parts of Trichy and Dharmapuri districts of Tamil Nadu face this problem. Old varieties : SR 26 B, Gettu, Dasal. Latest Co 43 (Dasal x IR 20), ADT 35, TRY 1, TRY 2 7. Resistant to Diseases: Blast, Helminthosporium, bacterial leaf blight, Tungro virus are some of the important diseases . Blast resistant varieties : IR 20, Medium duration Co 37 - short duration Co 25 - Long duration 7 Grassy stunt : O. nivara. Blast and BLB : O. minuta tetraploid. resistant Co 45 - resistant to RTV, Blast and BLB. PY 3 - RTV, BLB 8. Resistant to pests: Brown plant hopper, Stem borer, Rice gall midge are important pests. Stem borer donor : TKM 6 IR 20, (IR 262 x TKM 6) PY 3 - Bharathidasan - Resistant to BPH O.officinalis BPH Resistant 9. Improved grain quality a) Grain shape size and texture Rice cultivars can be classified based on the size, shape and texture of the grain. According to FAO the trade grades are Length : Extra long - over 7 mm length Long - 6 to 7 mm Medium - 5 to 5.99 mm Short - below 5mm. Shape : Based on Length / Breath ratio.(L/B ratio). Basmathi, Ponni, Slender - over 3 L/B IR 20 Medium - 2.0 to 3.0 L/B Co 37 Bold - 2.0 to 2.39 L/B Texture : Two main types are recognised 1. Hard starchy grain with (translucent) vitreous fracture 2. Soft dextrinous grain with opaque fracture. Known as glutinous rice. Hard starchy types are the major one consumed. They differ in their translucency, hardiness and presence or absence of abdominal white depending on starch content. They remain dry and flaky when cooked. Soft dextrinous grain become sticky and clot on cooking and usually used for special dishes (puttu rice). These types are preferred by people using chop sticks for eating. b) Aroma and Cooking quality: Some varieties give aroma when it is cooked. Varieties like Basmati scented rice there will be elongation in the cooked rice also. The aroma is due to certain chemicals present in endosperm. An alkaloid PANDAMARILACTIONE is the cause of fragrance. This alkaloid is present in the leaves of Pandanus also. E.g. Basmati 370 Zeeraga Samba ADT41 8 Kalabath Seetha bogam The cooking quality vary with the variety and grain type. Long grain varieties remain dry and flaky when cooked, while medium and short grain varieties are sticky and chewy. Preference for a particular variety differs with use. In evaluating rice varieties cooking tests are conducted for a) amylose content, b) Water absorption properties c) gelatinisation test. d) grain elongation ratio e) protein content f) par boiling quality g) milling out turn. c) Nutritive value : Protein in brown rice is about 8%

while in polished rice it is about 7% Inheritance of protein content is complex. It depends on environment and nitrogen application. When protein content is increased there will be lowering of lysine content. d) Colour of kernel : The preference for particular kernel colour varies with region to region. In Kanyakumari and Kerala red rice is preferred. Depending on local needs the varieties are to be evolved. TKM 9 - Red rice, (TKM 7 x IR 8) e) Milling out turn The unhusked rice grain is known as Rough rice or paddy. The miller converts it to brown rice by scouring off the outer bran layer. The value of rough rice depends largely on its milling quality which is determined by head rice and total rice that is obtained from rough rice. Head rice : Whole grain and large broken pieces. Total rice : includes all rice recovered after milling. 10. Breeding for alternate source of dwarfing gene All the present day cultivars are result of breeding with dwarfing gene Dee - Gee - Woo - Gen there is danger in using the same source. If Dee - Gee - Woo - Gen becomes susceptible to a new pest or disease, the whole programme will collapse. So it is necessary to seek alternate sources of dwarfing gene. Efforts are underway to identify alternate source thro' conventional and non - conventional breeding techniques. 11. Breeding varieties suited for direct sown conditions. This again a location specific problem. In cauvery delta region getting cauvery water becomes an uncertainty these days. To minimize water requirement direct sowing 9 of rice is recommended. The varieties for direct seeding must be quick growing and suppress weed growth. 12. Varieties suited for dry land conditions In certain parts of Ramnad and Chengalpet rice is grown as dryland crop. Local land races like kurivikalayan and puttu rice are grown. To suit these needs varieties are to be evolved. 13. Deep water paddy: Areas in tail end parts of cauvery delta need deep water paddy. It is again a location specific problem TNR 1 and TNR 2. 14. Varieties suited for export The scented rice Basmati 370 is exported to Arab countries. The limitation in this programme is Basmati 370 grown in all areas cannot be exported. The importing countries prefer the Basmati Rice grown is valleys of Himalayan Range only. The rice grown in those area alone pass the chemical test. This must be due to effect of environment. Efforts are underway to identify export quality scented varieties grown in other parts of the country. 15. To breed varieties to control wild rice: This again a location specific problem.. In states of Bihar, Maharastra, Madhya pradesh and Punjab the wild rice O. sativa var. fatua is often creating problems. So it is necessary to have marker genes in cultivated rice to isolate them from wild ones. Purple colour stem is a marker. 16. Breeding varieties to suit any other local problems. E.g. - to identify varieties to cultivate in areas of turmeric cultivation where a short duration 70 days rice variety can be fit in between two turmeric crops Satari - short duration (70 days).

RICE VARIETIES RELEASED USING DIFFERENT BREEDING TECHNIQUES 1. Introduction : All the IRRI Rice varieties from IR 8 to IR 72. Other Examples are Basmati from Punjab, Ponni (mashuri) from Malaysia, CR 1009 (Ponmani) from Orissa. 2. Pure line selection : Co 9. Short duration Co 32. Thiruchengodu Samba - Medium duration Co 19. Chengalpattu Sirumani - Long duration 3. Hybridization and Selection : a) Pedigree method i) Inter varietal: Co 37 Vaigai TN 1 x Co 29 - Short duration. Co 41 CuL 2410 x IR 22 - Short duration Co 43 Dasal x IR 20 - Medium duration. Co 44 ASD 5 x IR 20 - Medium duration, suitable for late planting. Co 45 Rathu Heenathi x IR 3403 - 207 - 1 - Medium duration, Resistant to blast, BLB and RTV. Ponmani (CR 1009) Pankaj x Jagannath - Long duration. ii) Inter-racial Japonica x indica cross ADT 27 (Norin 10 x GEB 24) Ponni (Mashuri) (Taichung 65 x ME 80) iii) Inter specific crosses Co 31 (O.perennis x GEB 24) Drought resistance. IR 34 Complex cross, one of the parent is O.nivara b) Back Cross Method of breeding Co 37 male sterile line. Sabarmati and Jamuna. 4. Mutation breeding : a) Spontaneous mutation GEB 24 - From Athur Kichili Samba known as KONAMANI, fine grain and quality rice. ADT 41 - Dwarf mutant of Basmati 370. b) Induced mutation : Jagannath rice from Orissa. Semi dwarf. Parbhani - from Maharastra Prabavathi - Satari - Short duration, gamma irradiated AU 1 - from Tamil Nadu. 5. Heterosis breeding CORH 1 IR 62829 A / IR 10198 - 66-2 R CORH 2 IR 58025 A / C 20 R ADT RH 1 IR 58025 A / IR 66 R 11 IMPORTANT RICE VARIETIES SUITABLE FOR TAMIL NADU Short duration Name Parentage Duration (Days) TKM 9 TKM 7 x IR 8 105 Co 37 (Vaigai) TN 1 x Co 29 115 ADT 36 Triveni x IR 20 110 IET

1444 TN 1 x Co 29 115 PY 2 Kannagi x cu 12032 115 IR 50 IR 21153-14 x IR 28 Y 110 IR 36 Multiple cross derivative 120 TPS 1 IR 8 x Katti Samba. 115 PMK 1 Co25 x ADT 31 115 ASD 16 ADT 31 x Co 39 115 ASD 17 Multiple cross derivative 110 ADT 37 BG 280 - 1-2 x PTB 33 105 IR 64 Multiple cross derivative 115 ASD 18 ADT 31 x IR 50 110 ADT 41 Dwarf mutant of Basmati 115 ADT 39 IR 8 x IR 20 125 ADT 20 IR 18348 x R 25869 x IR 58 110 ADT 43 IR 60 x White Ponni 110 TKM-11 C 22 x BJ 1 120 Co 47 IR 50 x Co 43 110-115 Medium duration. IR 20 IR 262 x TKM 6 135 Bhavani Peta x BPI 76 135 Paiyur - 1 IR 1721 - 14 x IR 1330 - 33 - 2 150 Co 43 Dasal x IR 20 135 Co 44 ASD 5 x IR 20 135 Ponni, White Ponni Taichung 65 x ME 80 140 12 MDU 2 Co 25 x IR 8 135 ADT 38 Multiple cross derivative 135 ADT 40 RPW 6.13 x Sona 145 Co 45 Rathu Heenathi x IR 3403 - 261 - 1 140 TKM 10 Co31 x C 22 135 TPS 3 RP 31-492 x LMN 140 PY 6 (Jawahar) IR 8 x H4 135 Co 46 T 7 x IR 20 125 Long duration : Ponmani (CR 1009, Savithri) Pankaj x Jagannath. 155-160 ADT44 Selection from OR 1128-7-S1 145-150 Rice Hybrids CoRH 1 IR 62829 A / IR 10198-62-2-R CoRH 2 IR 58025 A / C 20 R ADTRH 1 IR58025A / IR 66 R 13 HYBRID RICE The utilization of the dwarfing gene (d1) from the mutant variety Dee-Gee-WooGen (DGWG) discovered in Taiwan in 1960s led to the development of Semidwarf, high tillering, nitrogen responsive, high yielding varieties of rice throughout the world. Consequently the yield level of rice in the tropics raised even 8-10 t/ha. Close observation of the yield performance of HYVS had revealed that the realised yield in such varieties are showing a plateauing trend (De Datta, 1990; Pingali et al; 1990). Among the various strategies proposed to break the yield plateau in rice productivity, exploitation of heterosis through the development of rice hybrids had been proved to be successful. Heterosis in rice was reported by Jones in USA as early in 1926 and Ramaiah in 1933. But the research work on hybrid rice was initiated in 1964, in China by Yuan Long Ping (Father of hybrid Rice). The identification of 'Wild Abortive' or 'WA' type cytoplasmic male sterility in 1970 was a breakthrough in hybrid rice breeding. In 1971 China accepted Hybrid Rice Research as a national cooperative project and in the year 1976, hybrid rice became a reality in China, for the first time in world, by the release of commercial rice hybrids suited for sub-tropical and temperate zones. Since then many of the rice growing countries had accepted the strategical approach of exploitation of heterosis through the development of commercial rice hybrids. And as such rice hybrids were released in countries like Vietnam (for subtropical zone), Korea (for temperate zone); besides these countries, research on hybrid rice is progressing in countries like Philippines, Indonesia, Malaysia, Thailand, United States, Egypt, Colombia and Brazil. Although research on the commercial utilization of heterosis in rice has made tremendous gains during the last 20 years, it is still in its infancy stage because the high yield potential of hybrid rice has not been fully tapped yet. And hence various approaches are adopted in major rice growing countries of the world to maximize the yield potential advancements of hybrid rice production. Breeding techniques for developing hybrid rice involve the following: a) Three-line method or CGMS system This system now a days known as CMS system, involving three lines vizcytoplasmic, genic male sterile line (A), maintainer line (B) and restorer line (R) is the most commonly used method in China and outside. Until 1985, more than 95% of the CMS lines used in the commercial indica rice hybrids, were of CMS-WA type which make the hybrid rice vulnerable to biotic and abiotic stresses. And hence attempts to identify new sources of male sterile cytoplasm led to the identification of CMS system like GA (Gambiaca), Di (Disi), DA (Dwarf wild rice), BTC (Chinsurah Boro II) and IP (Ido Paddy 6). Mechanism of male sterility maintenance and hybrid seed production in three-line system given in figure-1. Many years experience had undoubtfully proved that the CGMS system involving sporophytic and gametophytic male sterility is an effective way of developing hybrid rices and will continue to play an important role in the next decade. However there are some constraints and problems in such a system. The most serious is that yields of existing hybrid rice varieties including newly developed ones, have stagnated (Yuan, 1994). They have already reached their yield plateau, and are unable to increase the yield 14 potential through this approach and hence new methods and materials were adopted. In this regard two-line hybrids are promising ones, to raise the yield ceiling in hybrid rice. b) Two-line method of rice breeding Two-line hybrids can be evolved through - Mechanical

means - Application of gametocides - Use of cytoplasmic male sterility (CMS) - Use of genic male sterility (GMS) - Use of environmentally induced genic male sterility (EGMS) In rice EGMS system is commonly used. In EGMS systems two kinds of rice lines are made use of viz. PGMS (Photosensitive Genic Male Sterility) and TGMS (Thermosensitive Genic Male Sterility) which had been developed successfully in China. In this system male sterility is mainly controlled by one or two pairs of recessive nuclear genes and has no relation to cytoplasm. Developing hybrid rice varieties with these system has the following advantages over the classical CMS system, as given below. - Maintainer lines are not needed. - The choice of parents for developing heterotic hybrids is greatly broadened. - No negative effect due to sterile cytoplasm - Unitary cytoplasm situation of WA will be avoided. In this system the exploitation of heterosis can be achieved by developing intervarietal and intersubspecific F1 hybrids. In 1991, China had released hybrid combinations using this approach, and some of these combinations out yielded the best existing hybrids by 10-20% (Yuan, et al; 1994) Detailed studies about physiological and ecological requirements of EGMS lines had been made in China and Japan. Work is progressing in India and International Rice Research Institute, in Philippines to identify best suited rice hybrids through this approach, for commercial exploitation. TGMS system is considered useful in tropical and subtropical regions where as PGMS system is useful in temperate regions. Other possible approaches to develop two-line hybrid breeding system includes identification of a genic male sterility system which would revert to male fertility response to application of growth regulators and also the chemical induction of male sterility. c) One-line method of rice breeding Rice hybrids can be developed and popularised through the following concepts - Vegetative propagation - Micro propagation - Anther culture hybrids - Apomictic lines Among the above for large scale cultivation, apomictic lines and anther cultured materials will be economical. 15 CGMS SYSTEM IN RICE A line rf1 rf1 S rf2 rf2 Maintenance A line B line S rf1 rf1 x F rf1 rf1 rf2 rf2 rf2 rf2 Male sterile Male fertile S rf1 rf1 rf2 rf2 Male sterile A line Hybrid rice production S rf1 rf1 x F Rf1 Rf1 rf2 rf2 Rf2 Rf2 A line R line S Rf1 rf1 Rf2 rf2 Fertile F1 Hybrid rice 16 Hybrid rice breeding in Tamil Nadu : Hybrid rice research in Tamil Nadu was started as early as in 1979 at Paddy Breeding Station, Coimbatore before the Chinese achievements were known to others. The first male sterile line identified from a cross between CO 40 / Jeeraga Samba was of Genetic male sterile line which was maintained upto 1984 through stubble planting until Chinese and IRRI, male sterile lines were introduced. New Cytoplasmic Genic Male Sterile Lines were introduced to India as intensification of hybrid rice research at IRRI and its NARS, IRRI took leadership in introducing the CGMS lines such as V20A, V41A, ZS97A, Er-jiu-Nan 1A and Yar-ai-Zhao 2A from Hunan Hybrid Rice Research Centre, China and IRRI developed lines such as IR 46827 A, IR 46828 A, IR 46839 A, IR 46831A and 48483 A. Of these introduced lines Chinese lines were found not suitable and IRRI lines remained unstable for their sterility in Tamil Nadu. However, intensive research on hybrid rice was started during 1989 by ICAR with financial help of UNDP and FAO. This ICAR/ UNDP/FAO collaboration led to the establishment of a network for hybrid rice research among the 10 leading rice research centres of India. Paddy Breeding Station, Tamil Nadu Agricultural University is one among them. Intensification of hybrid rice research in TNAU resulted in the identification of a superior hybrid combination of IR 62829 A / IR 10198-66-2R named as TNRH 1. This hybrid has a duration of 115 days and out yields all the ruling short duration varieties. The variety release committee of TNAU recommended this hybrid for general cultivation in November 1993 and Tamil Nadu State Variety Release Committee endorsed the recommendation by releasing it as CORH 1 January 1994 and named it as MGR. TNAU has released three hybrids. Future strategies : Wide hybridization : Wide hybridization work in rice started as early as in 1934 to incorporate agronomically important genes available in wild species to cultivated varieties. A variety CO 31 was developed by crossing GEB 24 and O.perennis. Though there was a slow down in this approach during mid period between 1940 and 1996, the work on wide hybridization has been intensified with financial support from Department of Biotechnology. The major objective of this programme is to produce male sterile lines with diverse cytoplasmic bases and derivatives with good restoration capacity.

Tissue Culture : Work on rice tissue culture was initiated in 1978 with a major objective of synthesizing dihaploids through anther culture. The programme was successful and resulted in a promising culture from a cross combination of IR 50/ARC 6650. Attempts were made to find out the genotypic responses to tissue culture using wild species of rice and cultivated varieties. In vitro screening for salt tolerance was carried out. Most of these studies were carried out by the post graduate students of this Directorate. A dihaploid line from TNRH 10 rice hybrid is in the evaluation stage. The work is being further strengthened at the Centre for Plant Breeding and Genetics. Two line breeding for hybrid rice : For synthesizing rice hybrids, attempts to use temperature sensitive genetic male sterility (TGMS) and photoperiod sensitive genetic male sterility (PGMS) are made. To exploit this potential, a separate Hybrid Rice 17 Research Station has been established with financial support of Tamil Nadu Agricultural Development Programme (TNADP) at Gudalur in Nilgiris along with Coimbatore main centre. Hybrid rice research for salt affected areas of Tamil Nadu has also been programmed and Indian Council of Agricultural Research has already sanctioned a scheme on this line and work is in progress at Agricultural College and Research Institute, Trichy. Exploring apomixis : Apomixis is an alternative to dihaploids being explored to fix the heterosis in rice. Serious attempts are being made at IRRI. Our maiden attempt in this line helped us to develop protocols and establish our scientists and post graduate students to work in this new area of rice research. Besides this, attempts are being made to exploit potential of cytological techniques and molecular approaches to understand the phenomenon of apomixis. Molecular marker analysis : Molecular marker analysis is a new and useful tool for the rice breeders. The construction of molecular marker map of rice paved the way for mapping the rice genes to specific locations of rice chromosomes. A marker aided selection laboratory established at present will be utilized for mapping the genes controlling resistance to WBPH, BPH, quality traits and TGMS. A programme to map the favourable. Quantitative Trait Loci (QTLs) available in wild species responsible for yield and their components and transfer them to cultivated varieties is in progress. Finger printing of rice varieties will be another area of interest to catalogue all the accessions of rice, considering the wealth of germplasm available at Paddy Breeding Station, Coimbatore.

Hybrid Rice Seed Production Hybrid vigour in rice has been first reported by Jones (1926). This has led to speculation regarding the production of hybrid rice by utilising cytoplasmic male sterility. Most japonica rice has normal cytoplasm, but indica varieties with sterile cytoplasm and fertility restoring system have been identified. But difficulties have been encountered in obtaining sufficient seed set by cross pollination to make hybrid rice seed production economically feasible. After the implementation of UNDP/FAO project entitled "Development and use of hybrid rice technology in India" - the hybrid rice production in India has become a success story. Hybrid rice seeds were produced using (cytoplasmic genic male sterility) three line system. The two genes Rf1 and Rf2 are the genes for fertility restoration. The process of hybrid rice production involves continuous supply of agronomically improved cytoplasmic male sterile line (A), maintainer line (B) and fertility restorer (R) line in system. Maintainer and restorer lines are maintained by selfing, while CMS line and F1 seeds are produced with efforts to enhance cross pollination in field. F and S refer to fertile and sterile cytoplasm. Rf and rf are fertility restoring and non restoring gene respectively. Row ratio and spacing of A and R lines in the main field R R A A A A A A A A R R 0 0 * * * * * * * * 0 0 0 0 * * * * * * * * 0 0 0 0 * * * * * * * * 0 0 15cm 0 0 * * * * * * * * 0 0 30 cm 20 cm 15 cm (male : female ratio = 2 : 8) Technique of hybrid rice seed production The following points are to be taken in to account for a successful hybrid rice production. 1) Choice of field : Fertile soil, protected irrigation and drainage system, sufficient sunshine. No serious disease and insect problem. 2) Isolation : To ensure purity of hybrid seed and avoid pollination by unwanted pollen isolation is a must. a) Space isolation : No other rice varieties should be grown except pollen parent with a range of 100m distance. b) Time isolation : a time of over 20 days is practiced (The heading stage of other variety over a 100m range should be 20 days earlier or later over the MS line). c) Barrier isolators : Topographic

features like wood lot, tall crops to a distance of 30m/artificial obstacles of (plastic sheet) above 2m height. 19 3) Optimum time for heading and flowering Favourable climatic condition for normal flowering are (i) Mean temperature 24-28°C (ii) Relative humidity 70-80% (iii) Day and night temperature difference 8-10°C. (iv) Sufficient sunshine (v) Sufficient breeze. 4) Synchronization of flowering As the seed set on MS line depends on cross pollination it is most important to synchronize the heading date of the male and female parents. In addition, in order to extend the pollen supply time, the male parent is usually seeded twice or thrice at an interval of 5-7 days. 5) Row ratio, row direction and planting pattern Row ratio refers to the ratio of number of rows of the male parent to that of the female parent in the hybrid seed production field. The layout of row ratio depends on (i) The growth duration of the R line (ii) Growth vigor of the R line (iii)Amount of pollen shed and (iv) Plant height of the R line. The principles include * R line should have enough pollen to provide * the row direction should be nearly perpendicular to the direction of winds prevailing at heading stage to facilitate cross pollination. Practically, a row ratio of 2:8 is currently widely used in indica hybrid seed production. Generally, the R line is transplanted with two to three seedlings per hill and separated by a spacing of 15cm from plant to plant, 30cm from one row of restorer to another and 20cm from CMS line. The MS line is transplanted with one to two seedlings per hill with a spacing of 15x15 cm. A good population structure to get more seed yield is given below : a) Seedling/hill b) Hills/sq.m c) effective tillers/sq.m A line = 1-2 A line = 30 A line = 300 R line = 2-3 R line = 5 R line = 120 6) Prediction and adjustment of heading date Even if the seeding interval between both parents is accurately determined, the synchronization of their flowering might not still be attained because of variation in temperature and difference in field management. Hence it is necessary to predict their heading date in order to take measures as early as possible to make necessary adjustments by examining the primordial initiation of panicle. Adjustment of flowering date can be made by applying quick releasing nitrogen fertilizer on the earlier developing parent and the later developing parent should be sprayed with 2% solution DAP. By this measure a difference of 4 to 5 days may be adjusted. 20 7) Leaf clipping, gibberellin application and supplementary pollination These techniques are very effective for increasing the outcrossing rate. a) Leaf clipping : The leaves taller than the panicles are the main obstacles to cross pollination and, therefore, should be cut back. Generally leaf clipping is undertaken 1-2 days before the initial heading stage, and more than 2/3 rd of the blades of flag leaves are cut back from the top. b) Application of gibberellin (GA3) GA3 can adjust physiological and biochemical metabolism of rice plant and helps in hybrid seed production by stimulating the elongation of young cells. In most of the CMS lines, about 20-30% of spikelets of a panicle are inside the flag leaf sheath (exertion is only 70%). GA3 affects exertion of panicle completely out of flag leaf sheath. In India recommended dose of GA3 is 50g/ha using knapsack sprayer and 25g/ha with ultra low volume sprayer. Advantage of GA3 application * enhances panicle and stigma exertion * speed up growth of late tillers and increase effective tillers * flag leaf angle is increased * reduces unfilled grains * enhances seed setting and seed yield Spraying stage : 5% of panicle emergence Spraying time : 8-10AM is the best time. c) Supplementary pollination : Shaking the R lines panicles by rope-pulling or rod driving during anthesis can enhance the crossing rate. This is carried out during peak anthesis (10-12 AM). 8) Rogueing To get 98% purity of CMS lines and R lines, in addition to strict isolation, a thorough rogueing is also necessary. 9) Harvesting and processing - the male parent harvested first - care should be taken to avoid admixture of male and female lines. - female line should be threshed separately in a well cleaned threshing floor - seed field dried in shade to 12% moisture content - packed in suitable, cleaned gunny bags after grading Hybrid Rice CORH - 1 (MGR Rice) : Released in1994 Short duration, medium fine grain (Parentage : IR 62829A x IR10198-66-2R) Breeding method : Three line Breeding Season : May-June (Kar-Kuruvai) Duration : 110-115 days Yield : 6380 kg/ha Area of adaptation : Coimbatore, Madurai, Chengalput, Salem, Nagapattinam, Periyar Districts. 21 SEED PRODUCTION TECHNIQUES FOR CORH 2 HYBRID RICE Parentage : IR 58025 A x C 20 R Selection of Field : Previous crop should not be of rice. If previous crop is rice, irrigate the field and there by the

dropped seeds will germinate which can be puddled in. If the pervious crop is having dormancy means, we must be careful to see that the dropped seeds are all germinated and puddled in. Isolation distance : 100 meters. If time isolation is to be followed, there should not be any rice crop near by within 100 meters, in the process of flowering while the crop in seed production plot is in flowering. There must be a difference of 30 days in flowering for the near by crop. Season : April - May and Dec - January month of sowing. Seed rate : A line : 20 kg / ha R line : 10 kg / ha. Nursery : Apply 2kg DAP to the nursery. Adopt 1kg / cent of nursery for both A line and R line while raising the R line 5 kg seeds can be raised on the same date when A line is raised. The rest 5 kg can be sown five days after first sowing. Manuring of main field : 10 tonne FYM / ha N P K Basal dressing 50 kg/ha 60kg/ha 20kg/ha Tillering stage 50kg/ha - 20kg/ha Boot leaf stage50kg/ha - 20kg/ha Planting date : A line - 25 - 30 days after sowing R line - 20-25 days after sowing Planting Ratio : 8 rows of A line 2 rows of R line Spacing : A line : 10cm between rows 15 cm within rows Single seedling / hill B line : 30 cm between rows 15 cm within rows. Two seedlings / hill. The space between A line and R line is 20 cm 22 Plant protection : Follow the plant protection measures adviced for rice. Avoid spraying or dusting during anthesis and pollination i.e. early morning period. Rogueing and removal of pollen shedders : From the beginning rogueing is to be done in both A line and R line. Pollen shedders are to be removed along with tillers. In A line seed set may not exceed 40%. If plants having a setting of 70 to 80% means they are rogues and they have to be removed before harvest. Special techniques : i. Pulling of ropes across the plot ii. Shaking the R lines with bamboo poles. Harvest : Harvest the R line first. Then harvest the hybrid. Thresh it properly dry it with 12% moisture and bag it.

MAIZE Zea mays (2n = 20) Place of origin : Mexico. Origin of cultivated maize The genus Zea was previously considered as monotypic. Later on teosinte has been included Euchlaena mexicana has been changed as Zea mexicana Another wild relative is Tripsacum (gamma grass). All the three are inter crossable. Three views about origin 1. From Teosinte it arose. Teosinte is having cob and tassel and easily crossable. This theory was not accepted based on cytological studies. 2. Maize arose from pod corn Zea mays var. tunicata thro' natural mutation. This view is the most accepted one. But origin of pod corn is not known. 3. All the three came from common ancestor but this common ancestor lost during evolution. Ideal plant type in maize - Plant with up right leaves which will increase photosynthesis. - Extended grain filling period to have uniform well matured grains. - Cob with increased row no. > 15. - Multi cob plant Breeding objectives : 1. Yield : Complex character controlled by polygenes. Attention is to be paid to have ideal plant type. Varietial hybridization as a maize breeding method did not gain popularity. The main reason for this is difficulty in getting superior segregants. 2. Breeding for pest and disease resistance : Shoot fly, Stem borer, Heliothis are major pests. Mexican varieties are resistant. Downy mildews, leaf blight and helminthosporium are major diseases. Co1, CoH 2 are resistant. Taiwan lines are resistant to downy mildew. 3. Breeding for high protein : Composed of two fractions. a) Protein in endosperm known as Zein which is nutritionally not balanced since it is lesser in lysine and tryptophan. 80% protein found in endosperm. b) Protein in germ (embryo) 20% balanced one. By increasing the embryo size we can increase protein content. 4. Breeding for increased oil content. 12-15% in germ. By increasing the embryo size we can increase oil content. 29 5. Alternate sources of cytoplasm CMS - T. susceptible to helminthosporium C and S Resistant. 6. High yielding baby corn. Z.m. var. sachharata, Sweet corn. The green cobs can be eaten as salad. The cobs can be harvested 45 days after sowing. CoBc 1 is latest variety of baby corn. Breeding methods: 1. Introduction : Initially the varieties were all introduced one. Sikkim primitive 1 Sikkim primitive 2. Mexican line were first introduced during 16th century by portugeese 2. Mass Selection : Prior to 1945 mass selection was the only method used for maize improvement. KT 1 - U. P. RAS 1 - Rajasthan. By adopting mass selection technique it is possible to get yield increase by 19% per cycle. 3. Ear to Row Selection : First proposed by Hopkins for improving oil and protein content of maize. This method involves selection of a number of

phenotypically desirable ears out of a population grown in isolation. The selected cobs are harvested on single plant basis and keeping part of the seeds & remaining sown in rows. Based on the best performing rows during next season the reserve seeds are sown. This method is suitable for characters having high heritability like oil content and protein content. But it was not helpful to get increased yield. 4.Modified Ear to Row method : Proposed by Lonquist. I. Best ear heads from population selected (100 No.) and harvested on single plant basis. And threshed individually. II. The single heads harvested are raised in progeny rows in more than one location representing different environment with local checks. III. In the main station the progeny rows are used as crossing block. Pollen from best plants are collected, mixed and used for crossing the rows. Select best five plants from each rows and harvest them separately record the yield. On the basis of performance of over all locations only top 20% progenies are selected. These 20% will include the five plants selected. 30 IV. The seeds from 5 plants selected are sown in progeny rows and cycle is repeated. 5. Hybridization and Selection Not popular since isolation of superior recombinants was not made. 6. Heterosis breeding : Instead of using CGMS lines, detasseling the female inbred line is followed in India. Since use of CGMS line is costlier compared to detasseling it is not followed. Crossing the inbreds of indigenous x exotic origin resulted in release of best hybrids. Indian x Indian - 24 to 43% yield increase. Indian x U.S. dent 58 % Indian dent x Caribbean Flint 47 to 54 % 1. Single cross hybrid - CoH 1, CoH 2. 2. Three way cross hybrids - Ganga -5 3. Double cross hybrids - CoH 3 4. Double top crop hybrid - White kernel hybrids - Ganga safed 2, Histarch, Ganga 4. 7. Population Improvement : Recurrent selection technique was initiated by Dhawan in 1963. The initial synthesis of composites were done from high yielding inter varietal crosses which exhibited minimum inbreeding depression. Kisan, Jawahar, Vikram, Sona, Vijay, Amber. Co 1 K. 1 Future thrust 1. Development of broad based, genetically diverse gene pool of populations. 2. Evaluation of the performance of these base populations thro' recurrent selection procedure. 3. Development of superior inbreds. 4. Development of superior hybrids.

SORGHUM Sorghum bicolor (2n = 20) Origin : Africa Progenitor of sorghum 1. S.arundinaceum 2. S.verticilliflorum 3. S.sudanense 4. S.aethiopicum Classification : Right from 16th century there were number of classification for the genus sorghum. The famous among them is Snowden's classification (1936) later refined by Garber (1950) and by Dogget (1970). SORGHUM Section I Section II Sorghum (True Sorghum) Para sorghum (other Sorghum) S.versicolor S.introns Sub section Sub section S.purpureosericeum Arundinaceae (2n=20) Halepensia (2n=20, 40) S.nitidum S.halepense S.plumosum S.miliaceum Series Series S.almum Spontanea(grass) Sativa(grain) S.propinquum S.sudanense S.vulgare S.radolphianum S.aethiopicum S.subglabaesence S.virgatum S.dochna S.verticillifolium S.stapfii The latest classification was done by Harlan and De Wet (1972). 32 1.Bicolor (B): Grain elongate, glumes clasping the grain which may be completely covered or ¼ exposed. 2.Guinea (G): Grains flattened dorso-ventrally. 3.Caudatum(C): grains asymmetrical, glumes 1/2 the length of the grain. 4.Kaffir (K): Grains symmetrical (spherical), glumes clasping in varying length. 5.Durra (D): Grains rounded obovate, wedge shaped at the base and broadest slightly above the middle; glumes very wide. Fig.1. Five basic races of sorghum based on coverage of glumes According to them, the cultivated sorghum Sorghum bicolor is divided in to five basic races based the coverage of glume on the grain (Fig 1). Hybrid races : This consists of all combinations of the basic races. 1.Guniea bicolor (GB) 6.Guinea kaffir (GK) 2.Caudatum bicolor (CB) 7.Guinea durra (GD) 3.Kaffir bicolor (KB) 8.Kaffir caudatum (KC) 4.Durra bicolor (DB) 9.Kaffir durra (KD) 5.Guinea caudatum (GC) 10.Durra caudatum (DC) Wild Sorghum sp. of Tamil Nadu: S.halapense : Both 2n = 20 and 2n = 40 forms are available utilized for forage sorghum improvement. S.sudanense : Utilized for improvement of forage sorghum. S.nitidum : Found in Kodai Hills. Processes shoot fly resistance and dormancy. S.staffii : Found in Southern districts, used for inducing dormancy. Cultivated sorghum Grouped in to two a) Tall, tropical late maturing adapted to short day length photo sensitive, longer internodes. E.g. Land races. 33 Land races of sorghum 1. Peria manjal cholam - 2. China

manjal cholam - 3. Sen cholam 4. Talaivirichan cholam 5. Vellai cholam 6. Irungu cholam 7. Makkattai b) Temperate, dwarf plant adapted to longer day length, photo in sensitive, shorter internodes, long panicles, high yielding varieties. Breeding objectives 1. High yield : Productivity genes are present in durra, roxburghi, Caudatum and Zera - Zera. Direct components : Panicle length and breadth panicle weight, number of primary branches, number of seeds / panicle and 100 seed weight. Indirect components : Plant height, leaf area index endosperm texture. 2. Short duration - to fit in multiple cropping programme. Co22 is the shortest duration having a duration of 70 days. The drawback in this variety is it is dwarf and farmers who are in need of cattle feed may not cultivate this. 105 - 100 days is optimum. This can be grown in two seasons instead of a long duration land race. E.g. Co25 - Co 26. Tropical lines having dominant maturity gene Ma and temperate lines having recessive ma gene. 3. Breeding drought resistant varieties with low HCN content in the early stages of growth : 75% of sorghum is grown under rainfed condition. It is highly essential to breed varieties, which can with stand initial as well as terminal drought. Further in dry land varieties there will be high HCN content in the stem during early vegetative phase. This limits the use of varieties as cattle feed. To over come this it is essential to breed varieties with low HCN content. Low HCN content exhibits partial dominance reaction. More than one gene involved in controlling this trait. 4. Breeding non - lodging sorghum This is essential for southern districts, The hybrid sorghum kovilpatti tall (90 days duration) grown during N.E monsoon has a tendency to snap at nodes and lodge at maturity. This leads to considerable loss. To replace this the new hybrid COH3 having duration of 105 days was introduced. But it was not suitable because it could not withstand terminal drought. Dwarf character is conditioned by genes DW1 to DW4. 34 5. Resistance to pests Shoot fly, stemborer, midge and earhead bug are the important pests of sorghum. Sources like S. nitidum, S. virgatum are available against pests. Some of the land races like local irungu cholam are resistant against shoot fly. Efforts are under way to evolve resistant varieties. Resistance may be - Non preference for oviposition because of presence of trichomes. Antibiosis - Silica content in the plant body Recovery resistance by producing side tillers. 6. Resistance to diseases : Sorghum downy mildew, helminthosporium blight, grain mould are the important diseases. The inheritance is complex and poly genic. 7. Breeding for sweet sorghum Because of self sufficiency in rice, use of sorghum as human food is fast dwindling. So to find out alternate uses for sorghum, breeding sweet sorghum is one strategy. From the stem juice, ethanol can be produced which is a renewable source of energy. Brazil stands first in this. There are two types of sorghums. a) Syrup varieties - Syrup for table purpose can be produced from this. This is also suitable for ethanol production. b) Sugar varieties : contains more of sugars and less of combustible organics. Not suitable for ethanol production compared to syrup varieties. Normal sorghum contains 12 %, TSS (Brix) where as sweet sorghums contain around 18% TSS. The juice will be extracted and sterilised. After sterilisation the juice is treated with yeast. After 48hrs, distillation is done to extract alcohol. Around 45% alcohol is recovered. 8. To breed red grain varieties suitable for biscuit making Madurai - Tirumangalam area biscuit is made from Sencholam Salem - boiled red grain used for consumption. The variety Paiyur 2 is a red grain variety. 9. Breed varieties with nutritional quality : Normal protein = 7-8 % with 1.9 to 2.5% lysine, 9.3 to 11.6% leucines Increase in protein upto 12% is possible, but the problem is disability. Two high lysine Ethiopean lines IS 11167 and IS11758 with 15% protein. The hl gene is monogenic recessive and seeds are shrivelled and red in colour. 10. To satisfy local needs Small pearly white grain is used for preparing ‘Kali’ which has high keeping quality. S.roxburghi (Talai virichan cholam) is suitable and is grown in many districts. The varieties Co19 and Paiyur 2 are examples. 11. To isolate alternate sources of cytoplasmic genic male sterile lines. The existing CMS lines are having A1 cytoplasm as base. There are other sources viz., A2 , A3, A4 and A5. But all of them are in grassy sorghum and susceptible to 35 foliar diseases. This we have to improve. There are local ones like Maldandi 35 GA, G.I.A. but they are season bound and long duration. Breeding techniques : Sorghum is often cross pollinated crop. So to maintain varietal purity isolation distance of 400 meters is necessary. Compared to other often pollinated crop like red gram,

maintenance of inbreds is easy in sorghum. By putting brown paper and selfing the genetic purity can be maintained. 1. Introduction : Varieties of milo and kafir sorghum introduced from USA are used in conversion programme to convert the local long duration photo sensitive varieties to short duration, non-photo sensitive lines. 2. Selection : Old varieties like Co1, Co2, Co4 are all selection made from local land races. 3.Hybridization and selection a) Inter varietal (IS 4283 x Co 21) x CS 3541, Three way cross derivative Co 25 (MS 8271 x IS 3691) - Single cross derivative Co26 b) Inter specific Co 27 Sorghum. (Co11 x S.halapense) 4. Heterosis breeding : Use of CMS lines. CSH 5 2077 A x CS 3541 CoH 4 296 A x TNS 30 5. Mutation breeding : X ray mutant from CSV 5 (148) Co21 (699 Tall) Co 19 is a natural mutant from Co 2 6. Back cross method : Co 20 peria manjal cholam. (Bongan hilo x Co1 Peria manjal cholam). Co20 Peria manjal cholam. Striga resistance was evolved by back crossing. By following backcross method of breeding sorghum conversion programme was initiated. The long duration photosensitive germplasm was converted in to photo insensitive short duration sorghums. This was done at USA Similar programme was done at ICRISAT also. 7. Population improvement : With the use of cytoplasmic genetic male sterility as well as genic male sterility we can go for population improvement. The local land races can be used as pollinators and by half sib family selection, we can isolate lines. We can follow recurrent selection idea to develop superior inbreds. 36 8. Use of Apomictic lines : Some apomictic lines have been identified which can be utilised in breeding programme and by vegetative propagation we can fix up heterosis. E.g. R473 from Hydrabad. Future thrust 1. Characterisation of released varieties and hybrids. 2. Differentiation of A1, A2, A3 and A4 cytosteriles thro' molecular markers 3. Diversification of male sterile lines. 4. Use of Apomictic lines to develop hybrids. Sorghum varieties suitable for Tamil Nadu. Variety Parentage Duration K5 Reselection from IS 3541 95 K7 K3 x M 35-1 110 Co19 (Talaivirichan cholam) mutant from Co 2 145 Co 25 Three way cross derivative 105 Co 26 MS 8271 x IB 3691 110 Co 27 Co 11 x S.halapense 60 Co21 mutant of CSV 5 105 K 8 IS 12611 x SPV 105 85 K 9 M 36200 x Tenkasi vellai 120 K 10 K 7 x SPV 102 115 K 11 K 7 x A 6552 115 Paiyur-1 Co19 x Co24 145 BSR - 1 multiple cross derivative 110 Paiyur 2 (Sencholam) PLS from IS 15845 95 Hybrids : CoH 2 (Kovil Patti Tall) 2219 A x IS 3541 90 CoH 3 2077 A x Co 21 110 CoH 4 296 A x TN 30 110 CSH 5 2077 A x CS 3541 100.

FINGER MILLET RAGI - Eleusine coracana Gaertn. (2n = 36) (Finger millet / Kezhvaragu / Keppai / Mutthair / Thamida / Nacheni / Mandal) Finger millet is an important staple food in parts of East and Central Africa, and India, particularly in Karnataka. It is used for malting and brewing. Place of Origin : India Classification : The genus Eleusine consists of eleven species. Of these six are diploids and five are tetraploids. Eleusine indica is a diploid with 2n = 18. Eleusine coracana and E.africana are tetraploids (2n = 36) Origin of cultivated species: E. indica is considered as one of the parent for the tetraploid E.africana. E.coracana were mutants selected from of E. africana. E. indica.diploid (2n=18) x Closely related taxon Chromosome doubling E. africana (2n =36) introgression mutant E. coracana (2n =36) tetraploid Hybridisation and introgression between E.coracana and E.africana continued and still continues in the highlands of Tropical Africa Characters of Eleusine: Inflorescence is contracted into a number of digitate spikes of spikelet. Spikelet consists of more than two florets subtended by two glumes. Cultivated types of Ragi : There are two cultivated types of ragi. 1.Indian ragi, E. coracana and 2.African ragi , E. africana. African ragi : It has long fingers, bold grain, stiff straw, photo sensitive and uneven grain maturity phase. Indian ragi : Short fingers, small grains, photo insensitive. 38 RAGI (Finger millet) Eleusine Coracana (2n = 36) Origin : According to Krishnaswamy(1952) the cultivated species of E.coracana arose as a allotetraploid from its wild relative E.indica. Asia and Africa are supposed to be place of origin. The African types are having bolder grain. Wild relatives : The genus Elevsine comprises of 11 species of which 6 are diploids and 5 are tetraploids. 1. Eleusine indica 2. Eleusine oligostachya 3. E.tristachya 4. E. poranansis 5. E. jaegeri 6. E. flacifolia (2n = 36) 1. Eleusine coracana 2. E. africana 3. E. longipoides 4. E. verticillata 5. E. cagopoides Breeding objectives : 1. Evolution of 80 days duration ragi suitable for irrigated conditions. 2. Breeding short duration drought resistant varieties suitable for

rainsfed conditions 3. Breeding for high protein white ragi varieties suitable for malt making. 4. Blast resistant varieties. 5. Breeding varieties for sodic soils and tannery effluent affected soils. Breeding techniques 1. By introduction Indaf 5 Ragi from karnataka. 2. By selection Pure line selection. Earlier varieties were all evolved by pure line selection. Co7 Co11 Co12 Paiyur 1 TRY I 3. Hybridization and selection The African types are with long fingers, bold grain with stiff straw. Further they are photosensitive and have un even grain maturity. Because of this character they are 39 not recommended for cultivation in India. The Indian types are with short fingers, small grains and photo insensitive. The African types are utilised in hybridization programme, to develop extra long fingered varieties coupled with disease and drought resistance. The Indian African cross derivatives are known as Indaf varieties which are interspecific. Other state varieties E.g. Indaf 5 cauvery x IE 929 Indaf 9 Tamil Nadu varieties Co6 white ragi IS 1540 x EC 2985 Co9 white ragi Co13 (Co7 x TAH 107) 4. Heterosis breeding : Artificial induction of male sterility through use of gametocide, GA3, 2-4-D are being attempted. 5. Mutation breeding : T20 - mutant from AKP - 7.

PEARL MILLET Pennisetum glaucum (2n = 14) (Cumbu, Bajra, Bulrush millet) Origin : West Africa. Taxonomy : The genus pennisetum is having more than 140 species. Stapf (1954) has divided the genus pennisetum in to five sections viz., 1. Gymnothrix 2. Eupennisetum 3. Penicillaria 4. Heterostachya 5. Brevivalvula The cultivated Pennisetum glaucum belongs to the section penicillaria. Origin and putative parents. Stapf included 32 species is penicillaria. Of these 32 species found is Africa, six annuals are considered wild and probable ancestors of the cultivated one. They are 1. Pennisetum perottettii 2. P. molllissimum 3. P. violaceum 4. P. versicolor 5. P. adonense 6. P. gymnothrix The cultivated species of pennisetum is believed to have originated thro' hybridization with in these six species. Wild species utilised in breeding : The other species in this section is P.purpureum a rhizomatus perennial having chromosome number 2n = 28 cumbu napier hybrid = BN1 Tetraploid x Diploid - Triploid. P. squamulatum (2n = 46) - Drought and cold resistant having apomictic line crossed with P.glaucum to evolve superior cold resistant fodder. P. orientale : used for transferring apomixis. P. setaceum P. violaceum : To transfer male sterile genes to P.glaucum Inter generic crosses : Buffel grass Cenchrus ciliaris or Pennisetum ciliare utilised to cross with cumbu for fodder improvement Breeding objectives : 1. Breeding for high grain yield To get high yields the following plant characters are necessary a) more number of tillers b) well filled, compact, long panicle. c) heavy grains. d) Uniformity of ripening. 41 Under irrigated conditions photo insensitivity and early maturity are essential for multiple and relay cropping. 2. Breeding for improved grain quality. It can be achieved by incorporating yellow endosperm to improve vitamin A content or white endosperm to improve protein content. 3. Breeding for drought tolerance : This can be achieved thro' evolving lines having shorter duration so that they can escape drought, lines with more adventitious roots, lines with high leaf water potential and high chlorophyll stability index are to be evolved. 4. Breeding for disease resistance Downy mildew is the major disease. Ergot and smut comes next. Of late, rust at late stage is also becoming a major problem. Lines having Local Bellary cytoplasm (732 A) are observed to be downy mildew resistant. 5. Breeding for alternate source of cytoplasm in male sterile lines. Original Tift 23 A evolved at Tifton, Georgia is highly susceptible to downy mildew. Because of this the HB series went out of cultivation. The indigenous 732 A obtained from Bellary is resistant. Similarly L 111A of Ludhiana is also tolerant. A1, A2, A3 and A4 are there 732 A belongs to A4 cytoplasm. 6. Breeding for sweet cumbu to have high forage value : The forage cumbu must have following characters. a) high sugar content in the stem juice b) Increased leaf number with more breadth. c) Digestibility. In this connection, short day plants with photo sensitiveness is preferred because they remain in vegetative phase for longer periods. It is ideal to breed dwarf varieties with reduced stem height Wild species utilised. P. purpureum P. squamulatum p. orientale p. ciliare Methods of breeding 1. Introduction : Hybrid bajra from Punjab. Tift 23 A from USA 2. Selection : Pure line selection : Co 2, Co 3, Mass selection the earlier released variety Co5 is result of mass selection. The variety Co6 is selection from Nigerian accession MS 7625 selected for high tillering, long panicle, dense

seed setting and bold seeds along with downy mildew resistance. 42 3. Hybridisation and selection Interspecific hybridisation. Pennisetum glaucum x P.purpureum Cumbu napier hybrids. 4. Heterosis breeding : Hybrid bajra In earlier days before the identification of male sterile lines utilising the protogynous nature hybrids were released. The hybrids were produced by sowing both parents in the ratio of 1:1. X1, X2 , X3 are examples for this. In this case two hybrids are obtained. After the discovery of cytoplasmic genic male sterile line Tift 23A by Burton in Tifton, Georgia led to development of hybrids. Earlier hybrids of India viz., HB1, HB2 to HB5 were produced utilising Tift 23 A. But due to susceptibility to downy mildew they went out of cultivation. Even before the discovery of CGMS lines by Burton it was discovered by Madhava Menon and his coworkers at Coimbatore. Unfortunately due to failure of publishing it was not recognised. To over come the problem of downy mildew male sterile lines L 111A and 732 A were isolated and at present used in breeding programme. X5 L111A x PT 1921 X6 732 A x PT 3095. X 7 L111 A x PT 1890 NHB 3 - 5071 A x J 104 There are number of CMS lines developed by private agencies like Nath seeds, Mahyco, Mahendra. 5. Population improvement : ICRISAT entry WCC 75 is an example for population improvement. This was developed from world composite by recurrent selection method. It was developed from derivatives of numerous crosses between diverse sources of germplasm and Nigerian early maturing land races known as 'Gero' millets. Another example is ICMV 155 of ICRISAT. At TNAU Composite Co7 was released during 1987. 6. Synthetic varieties : Synthetics are produced by crossing in isolation a number of lines tested for their GCA. E.g. ICMS 7703. It is a result of crossing between 7 inbred lines of India x African crosses 7. Mutation breeding At IARI Tift 23 A was gamma irradiated and 5071 A resistant to downy mildew was evolved. With this the hybrid NHB 3 was evolved (5071 A x J 104) 43 Future thrust : 1. Collection of un exploited land races and exotics, building up of germ plasm and utilising them. 2. Development of early maturing restorers with good combining ability. 3. Genetic and cytoplasmic diversification of male sterile lines. 4. Devising methodologies for wide hybridization and use of genetic engineering to evolve disease resistant varieties. Bajra varieties suitable for Tamil Nadu Variety Parentage Duration Composites K 3 Composite 85 Co 7 Composite 90 WCC 75 Composite 95 Hybrids X 6 732 A x PT 3090 90 X 7 L111A x PT 1890 90 NHB 3 5071 A x J 104 90 TENAI (Fox tail millet) Setaria italica (2n = 18) A. Floral biology Inflorescence is a spike, terminal, drooping. The spikelets are oval or eliptical in shape with two to three bristles. The spikelets contain two flowers partially protected by two membranous glumes. Lower floret with L1 and P1, sterile; upper floret with L2, P2, stamens three, styles two, fruit a caryopsis. B. Anthesis and pollination Flowering proceeds from the top downwards in the main panicle and similarly from the tip down wards in each of the panicle branches. The stigmatic branches are the first to emerge. The anthers after emergence start dehiscing by longitudinal slits from the top to bottom the process taking about three minutes. Five to ten minutes after the emergence of the first anther, the other two are pushed out. After pollination the lodicules shrink and the glumes begin to close. The time taken for an earhead to complete its flowering varies from ten to fifteen days. From the third to sixth day to emergence a large number of flowers open. There are two times of flowering during a day, one between 10 p.m. and 12 midnight and other between 6 a.m. and 8 a.m. Self pollination is rule.

VARGU (Kodo millet) Paspalum scrobiculatum (2n = 40). A. Anthesis and pollination The spikelets are highly cleistogamous. Only 10-15% of spikelets open under Coimbatore condition. Spikelets at the middle of spikes open first, gradually spread to either ends. Spikelets open after midnight i.e. from 2.30 AM to 3.00AM and continue till sunrise. KUDIRAVALI (Barn yard millet) Echilinochloa colona (2n = 34, 48, 54, 72) The spikelets are more or less crowded on the spike like branches of the panicle. The anthers are purple in colour. Order of flowering is from tip to the bottom of panicle. The total flowering period extends from 19-22 days. Anthesis - 5 AM to 10 AM. Self pollination is the general rule. Varieties : Pureline selection - RAU 3 PANI VARAGU (Proso millet) Panicum miliaceum Inflorescence is a drooping panicle. The spikelets contain two flower partially enclosed by the glumes. The flowers open between

10AM to 12 noon. The spikelets open and close with in 7 minutes. The anthesis begins from tip of the panicle and proceeds down wards. Flowering completes within 7 to 10days. Self pollination is the rule. Varieties : Pure line selection - BR 7 Emasculation and crossing technique in small millets Hand emasculation is tedious because of small sized florets. To over come this the Russian method is followed. The principle in this method is to induce artificial flower opening by increasing the temperature 1-20 C and immersing the panicle in normal cold water prevent anther dehiscence but flowers will open. Method i) Select the panicle which first commenced flowering ii) Remove the already opened florets iii) Rub the selected panicle in between hands to increase the temperature by 1 to 20 C for two minutes. iv) Immerse the panicle in cold water v) The flowers will open but anthers will not dehisce 45 vi) Take out panicle from water and remove unopened flower vii) From opened florets remove anthers Pollination: 1. Collect the panicle from male parent which are in the process of flowering. Shake the panicle on the emasculated florets. Tie the male panicle to the emasculated female panicle. Cover it with butter paper bag which was immersed in water. The water in butter paper bag will maintain humidity. Minor Millet varieties : Tenai Co 4 Selection from Gujarat local 70 days. Co 5 Co1 x A113/2 90 days. Panivaragu Co 4 Pureline selection 75 days. Kudiraivali Co 1 Pureline selection 75 days. Somai Co 2 Selection from Ananthapur local 85 days. Poriyu 2 Pure line selection 80 days Varagu K1 Pure line selection 100 days.