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CONTENTS

136 TABASSUM, R; RAJOKA, MI; MALIK, KA. 1992. **Use of chemostat for enhanced production of beta-glucosidase by newly isolated anaerobic cellulolytic *Clostridium* strain RT9**. *Applied Biochemistry and Biotechnology*, 34/35, 317-329.

137 TULI, R; SALUJA, J; NOTANI, NK. 1989. **Cloning and expression in *Escherichia coli* of entomotoxic protein gene from *Bacillus thuringiensis subsp. kurstaki***. *Journal of Genetics*, 68: 3, 147-160; 39 ref.

In a laboratory experiment, a plasmid-borne larvicidal crystal protein gene from *Bacillus thuringiensis subsp. kurstaki* was cloned in *Escherichia coli* using a specific 20-mer oligonucleotide probe. The gene expressed in *E. coli* at a high level. Transgenic *E. coli* cells produced large irregular bodies which were bright under phase contrast microscopy. These were released by sonic disruption of the cells and pelleted by centrifugation. In toxicity trials against the noctuid *Spodoptera litura*, 3rd-instar larvae were exposed to 35 mm castor (*Ricinus communis*) leaf discs treated with transgenic *E. coli*. An immediate effect was the cessation of feeding. A similar response, but to a lesser extent, was observed in larvae feeding on leaf discs treated with a spore-crystal supernatant preparation of *B. T. subsp. kurstaki*. Larvae showed severe growth retardation and no mortality. Larval weight decreased by 80% after feeding for 3 days on leaf discs treated with transgenic *E. coli*. This was greater than the 39% reduction caused by comparable amounts of protein in the spore-crystal preparation. Larval growth was retarded marginally (11%) by the *E. coli* control. The pupation of larvae in controls was complete by the 23rd day; however, the majority of larvae fed on toxin preparations remained in the larval stage. The delay in pupation was in proportion to the extent of the toxicity. Treated larvae required 9 extra days before pupation was complete. Mortality was observed only when the toxin was fed to newly exposed larvae.

FIELD CROPS

138 BAJAJ, YPS. 1983. **Haploid protoplasts**. *International Review of Cytology*, Suppl. 16, 113-141; 73 ref.

The isolation, culture and fusion of protoplasts from pollen tetrads and maturing pollen, the isolation of haploid protoplasts from mesophyll and callus cells, and the subsequent regeneration of these protoplasts into entire plants is described and a summary of this work is given in a table, comprising many plant species and including *Brassica napus*, *Nicotiana spp.*, potato, rice, wheat and oats. The implications and prospects of haploid protoplasts in the induction of genetic variability, mutations and somatic cell genetics are considered.

139 JALALI, SK; SINGH, SP; BALLAL, CR. 1987. **Role of the host plants of *Spodoptera litura (Fabricius)* on the degree of parasitism by *Cotesia marginiventris (Cresson)* (*Hymenoptera*: *Braconidae*)**. *Indian Journal of Agricultural Sciences*, 57: 9, 676-678; 3 ref.

Laboratory studies were conducted in India to determine the effect of host plants on the degree of parasitism of the noctuid *Spodoptera litura* by *Cotesia marginiventris* [*Apanteles marginiventris*]. Results of single-plant choice tests indicated that *A. marginiventris* had a marked preference for *S. litura* larvae on castor (*Ricinus communis*) (49.3% parasitism), followed by cowpea (*Vigna unguiculata*) (24.0%), tobacco (20.0%), okra (16.0%), cabbage (13.3%), knolkhol [kohlrabi] (10.7%), cauliflower (10.7%) and beetroot (9.3%). Although 20% of the larvae were parasitized on tobacco leaves, female parasitoids became very inactive after contact with the leaves and died within an hour. The sex ratio of *A. marginiventris* differed slightly on the various host plants. Results of multiple-plant choice tests indicated that given a choice of all the host plants at once, the parasitoid preferred the host on kohlrabi (56% parasitism), followed by cabbage (29.3%), castor (28.0%), cowpea (28.0%), beetroot (18.7%), cauliflower (16.0%), okra (10.7%) and tobacco (1.3%). In this test, the parasitoid showed least preference for larvae on tobacco. These results indicate that *A. marginiventris* would not be suitable for release against *S. litura* on tobacco.

140 MIAH, MAA. 1992. **Tissue culture; advances in crop science**. *Proc. on the First biennial Conference of the Crop Science Society of Bangladesh*. (Dhaka: May 18 20). Crop Science Society of Bangladesh. p. 294 299.

CEREAL GRAINS

141 AZIZ, JA; AZIZ, SA. 1985. **Food preference and the plant selection pattern in *Oxya velox Fab.* (*Orthoptera: Acrididae*)**. *Journal of Entomological Research*, 9: 2, 179-182; 7 ref.

The food preference of *Oxya velox* was evaluated in the laboratory at 30°C and 60% RH using 10 different plant leaves. The early instar hoppers preferred the grass to the cereal crops, while the reverse was found for late instar hoppers and adults. The descending order of preference for late instar hoppers and adults was a mixed diet of rice, *Cynodon dactylon* and *Echinochloa*

colonum, rice, wheat, *E. colonum*, *Hemarthria compressa*, *Setaria verticillata*, maize and pearl millet, while *Trifolium alexandrinum* was not fed upon at all. A bite into the leaf seemed necessary before a plant was rejected. It is suggested that preference for the plants is based upon a factorial complex including physical factors and the availability and chemical composition of the plants. It is suggested that since early instar larvae fed mainly on the grasses, removal of weeds could considerably restrict the population of *O. velox*.

142 BAJAJ, YPS. 1989. **Plant protoplasts and genetic engineering II**. *Biotechnology in Agriculture and Forestry, 9*. Berlin: Springer-Verlag, 499 p.

An introductory chapter reviews technical advances in this field. Chapter 2 contrasts generative and somatic genetic manipulation, while chapter 3 focuses on the uptake and intergration of exogenous DNA in plants. After a general consideration of DNA recombinants and transformation of agricultural crops, transformation of the following plants is considered: maize; rice; potato; cotton; *Populus*; *Vinca rosea*; *Hyoscyamus*; *Brassica*; and *Nicotiana plumbaginifolia*. Subsequent chapters deal with particular techniques: microinjection; electrofusion; apparatuses for electrogene mapping, electrophoresis and electrofusion; chloroplast genomes as genetic markers; flow cytometry; nuclei isolation and transplantation; chromosome transplantation; transferring mitochondria through protoplast fusion; incorporation of the luciferase gene into plant cells; uptake of viruses; uptake of fungal protoplasts; chloroplast uptake; cytoplasts; Vacuoles and miniprotoplasts. The thorough reference and subject indexing makes this, like its companions in the series, a useful guide.

143 BALYAN, HS; FEDAK, G. 1990. **Hybrids of an amphiploid (*Triticum timopheevii* X *Hordeum bogdanii*) with cultivars of *triticale* (*X Triticosecale Wittmack*)**. *Cytologia*, 55: 1, 65-69; 20 ref.

Hexaploid hybrids (2n = 6x = 42, AABGHR) between the amphiploid *T. timopheevii* X *H. bogdani* (female) and the triticale varieties Currency and Welsh were obtained at a frequency of 16.7 and 1.7% of pollinated florets, respectively, and showed a mean chiasmata frequency/cell of 13.85 and 14.42. Chromosome associations of up to 8 bivalents were observed at metaphase I. Pentavalent configurations were absent from the hybrid involving Welsh. Bivalent frequencies of >8 and low frequencies of multivalents were attributed to pairing betwen A, B, G and H genome chromosomes.

144 DAMANIA, AB; YAU, SK. 1991. **Biodiversity for useful traits in a genetic resources collection of barley**. *Barley genetics, 6: Vol. 1: Short papers: proceedings*. (Copenhagen: 1991: May)/edited by L Munck, K Kirkegaard, B Jensen. ICARDA, Aleppo (Syria) p. 9-11.

145 GUPTA, PK; FEDAK, G. 1985. **Meiosis in seven intergeneric hybrids between *Hordeum* and *Secale***. *Zeitschrift fur Pflanzenzuchtung*, 95: 3, 262-273; 27 ref.

Five *Hordeum species* (including 2x, 4x and 6x species, but not *H. vulgare*) were pollinated with pollen from *S. cereale* (3 cvs.) and 3 other *Secale species*. The hybrids produced were vegetatively vigorous and morphologically similar to rye, but completely sterile. With the exception of infrequent heteromorphic bivalents, there was no meiotic pairing between chromosomes of the 2 genera, indicating no homology between the parental genomes. However, the genomes of the *Secale sp.* promoted autosyndetic pairing among *Hordeum* chromosomes in hybrids involving *Hordeum* polyploids.

146 HUKMANI, P; TRIPATHY, BC. 1992. **Chlorophyll biosynthesis: spectrofluorometric estimation of protoporphyrin IX, Mg-protoporphyrin and protochlorophyllide**. *NATO ASI Series : Series A : Life Sciences*, 226, p. 259-264.

147 KOLE, PC; CHAWLA, HS. 1992. **Morphological and cytological variation in second somaclonal generation of barley**. *Indian Journal of Genetics and Plant Breeding*, 52: 2, 114-117.

148 KOLE, PC; CHAWLA, HS. 1993. **Variation of *Helminthosporium* resistance and biochemical and cytological characteristics in somaclonal generations of barley**. *Biologia Plantarum*, 35: 1, 81-86.

149 KONISHI, T; MATSUURA, S. 1991. **Geographic variation in esterase isozyme genotypes of Himalayan barley [six-rowed barley, covered barley, naked barley]**. *Barley genetics, 6: Vol. 1: Short papers, proceedings*. (Copenhagen: 1991: May)/edited by L Munck *et al.* Copenhagen: Munksgaard, p. 15-17.

150 RAM SINGH; MRIG, KK; CHAUDHARY, JP; SINGH, R. 1987. **Incidence and survival of *Mythimna* species on cereal crops in Hisar**. *Indian Journal of Agricultural Sciences*, 57: 1, 59-60; 5 ref.

The incidence of the noctuids *Mythimna separata* and *M. loreyi* on maize, sugarcane, pearl millet, Napier grass (*Pennisetum purpureum*), Johnson grass (*Sorghum halepense*), sorghum, oats and Sudan grass (*S. suda-*

nense) was studied in Haryana, India, in 1984-85. In September, pearl millet was the most seriously damaged crop with larval populations ranging from 1-3/plant, and leaf damage was observed on maize, sugarcane and Napier grass. After pearl millet and maize were harvested, sporadic leaf damage and isolated larval populations were observed on sugarcane and Napier grass in October-December indicating that these crops probably act as a link between the rainy season and winter cereals. Napier grass, oats, sugarcane, winter maize, barley and wheat were attacked in January-February, with the highest populations (35 larvae/m2) on Napier grass. The larval populations peaked twice, in September and February. *M. separata* was almost 3 times as abundant as *M. loreyi* in September, while *M. loreyi* was the more abundant species in February. Larval parasitism by the braconid *Apanteles sp.* was higher in September (41.2%) than February (0.6%).

151 SHARMA, RK; KOTHARI, RM. 1992. **Innovative application of corn steep liquor for the increased production of food grains**. *Technovation*, 12: 213-221.

152 SINHA, RP. 1989. **Induced variation in triticale following hybridization and mutagenesis**. *Crop Improvement*, 16: 1, 9-13; 6 ref.

Seeds of DTS702, DTS141A, DTS47-1 and Beagle and their 6 hybrids were treated with 0.01% N-nitroso-N-methylurea [N-methyl-N-nitrosourea]. M2, F2 and F2M2 generations were evaluated for plant height and 3 spike characters. Variation was highest in the M2 but no increase in variability of the F2M2 over the F2 population was noted.

153 TOMAR, SMS; VARI, AK. 1992. **Crossability of some wheat cultivars with *Hordeum bulbosum L.*** *Indian J. of Genet. and Plant Breeding*, 51: 4, 380-382.

Coix

154 KATIYAR, SK; CHENDAL, G. 1994. **High Frequency Somatic embryo genesis from immature inflorescence of *Coix aquatica Roxb***. *Second Asia-pacific Conference on agricultural Biotechnology*. (Madras: 1994: March 6-10). Directorate of Research Services, IGKVV, Raipur - 492 012 (M.P.).

155 SAPRE, AB; BARVE, SS; DESHPANDE, DS. 1985. **Cytological report on the spontaneous interspecific hybrids in *Coix L.* involving aneuploids**. *Cytologia*, 50: 4, 655-661; 16 ref.

Spontaneous interspecific hybrids which arose in aneuploid populations of *C. gigantea* (2n=18-24) grown in close proximity to *C. aquatica* (2n=10) had 2n=14-16, suggesting that aneuploid female gametes of variable chromosome number had been fertilized by *C. aquatica* pollen. Intergenomic chromosome pairing was observed in the hybrids (which were male-sterile but had some seed fertility), suggesting a close relationship between the parental species. The intragenomic pairing behaviour of the *C. gigantea* genome in the hybrids, together with the observation that *C. gigantea* nullisomics (2n=18) and monosomics (2n=19) are vigorous and fertile, is taken as an indication that *C. gigantea* may be a tetraploid.

156 SAPRE, AB; NAIK, AS; BARVE, SS. 1988. **Spontaneous allotetraploid of *Coix gigantea* X *C. aquatica***. *Current Science*, 57: 4, 191-192; 13 ref.

This allotetraploid (2n = 28) was detected among spontaneous hybrids between populations of *C. gigantea* (2n = 20) and *C. aquatica* (2n = 10). It has 10 *C. aquatica* and 18 *C. gigantea* chromosomes which showed homologous pairing (A-A or G-G) and also formed multivalents due to intergenomic pairing. The allotetraploid was completely sterile owing to abnormal chromosome pairing during meiosis (high multivalency, secondary association and chromosome stickiness). Chromosome pairing in the F1 hybrid (2n = 14) of *C. gigantea* (2n = 18) X *C. aquatica* (2n = 10) indicated that there was a close phylogenetic relationship between the 2 species. It is suggested that the allotetraploid did not display the fertility normally associated with allotetraploid hybrids of distantly related species due to close chromosome homology.

Wheat

157 ALAM, S; AMIN, MN; KHAN, MR. 1980. **Cytological effect of insecticide and gamma radiation on wheat**, *Var. Sonalika. Proc. 4th Ann.Bangladesh Sci.Conf. held at Rajshahi*, p. 66.

158 ARORA, A; SHARMA, DR; RANA, RS; SINGH, RK. 1983. **Cytogenetic investigations in tissue and cell culture of wheat**. *Current approaches in Cytogenetic*/edited by RP Sinha and U Sinha. New Delhi: Spectrum Publishing House, p. 215-219.

159 ARORA, A; RAND, RS; SHARMA, DR; SINGH, RK. 1980. **Response of cultured cell lines and whole plants to salt stress in wheat**. *Indian Jorunal Biochem. Biophys.* p. 191.

160 ASGHAR, M. 1991. **Cytogenetics of an intergeneric cross between *Triticum aestivum L.* and *Aegilops ovata L.*** UAF, Faisalabad (Pakistan) 77 p.

161 BAINS, SS; DHALIWAL, HS; GUPTA, SANJIV. 1992. **Selective resistance of short arm of chromosome 4E of *Agropyron elongatum* to *Erysiphe graminis f.sp. tritici* isolates**. *Wheat Information Service*, No. 74: 4-5; 11 ref.

A set of 8 wheat- *Agropyron elongatum* [*Elymus elongatus*] disomic and ditelo addition lines were evaluated against an isolate of *Erysiphe graminis* during 1990-91 using the detached leaf inoculation technique. The disomic addition line 4E was free from visible colonies of the fungus but resistance appears race specific. Addition line 4E exhibiting resistance to *E. graminis* from Punjab was susceptible to race(s) prevalent in Himachal Pradesh.

162 BAJAJ, YPS; GOSAL, SS. 1986. **Biotechnology of wheat improvement.** *Biotechnology in agriculture and forestry 2. Crops I*/edited by YPS Bajaj. Berlin: Springer-Verlag, p. 3-38, 250-280.

The following topics are reviewed: embryo culture; anther culture; callus culture; regeneration of plants; protoplast isolation, fusion and culture; cryopreservation of zygotic embryos, pollen embryos, cells and protoplasts; and the establishment of germplasm banks. An extensive list of published studies on in vitro culture in *Triticum* is provided.

163 BAJAJ, YPS. 1986. **In vitro regeneration of diverse plants and the cryopreservation of germplasm in wheat (*Triticum aestivum L.*)**. *Cereal Research Communications*, 14: 3, 305-311; 14 ref.

Immature embryos from the cultivar Kalyan Sona were cultured on a MS medium supplemented with 2,4-D. Shoot and root differentiation occurred after transfer of callus to a medium containing IAA and kinetin. Up to 10 plants were obtained from one callus. There was a wide range of morphological variation in the regenerated plants. Zygotic embryos, frozen with cryoprotectants at -196°C and subsequently thawed and cultured, had a maximum survival rate of 48.7%; anthers similarly treated had a maximum survival rate of 22.1%

164 BAJAJ, YPS. 1983. **Regeneration of plants from pollen - embryos of *Arachis*, *Brassica* and *Triticum spp.* cryopreserved for one year**. *Current Science*, 52: 10, 484-486; 7 ref.

Information on regeneration of plantlets from anther segments and pollen-embryos after preserving them in liquid N for 1 yr is given for *A. hypogaea*, *A. villosa*, *B. campestris*, *B. napus* and wheat.

165 BAJAJ, YPS. 1985. **Somaclonal variations and the cryopreservation of germplasm in wheat**. *American Journal of Botany*, 72: 6, 874.

Callus cultures raised from immature embryos of *Triticum aestivum cv. Kalyan Sona* on a 2,4-D medium, on transfer to an auxin-free medium or to a one supplemented with IAA and cytokinin, regenerated plants which on transfer to the field matured and set grain. These plants showed marked differences in height, size of the awns and fertility of the spikes. Pollen-derived ambryoids and immature zygotic embryos subjected to 196°C in the presence of a mixture of cryoprotectants (DMSO, sucrose, glycerol) showed a survival range of 19-48%.

166 BALYAN, HS; FEDAK, G. 1990. **Further evidence for the suppression of meiotic chromosome pairing by *Hordeum californicum***. *Cytologia*, 55: 1, 61-64; 21 ref.

Four F1 hybrids were recovered from the cross between *Triticum timopheevii* X *H. bogdanii* (female) and *H. californicum* X *T. aestivum* (male) at a frequency of 2.4% of pollinated florets. Mean chiasmata frequency/cell in each of the hybrid combinations was 7.61-8.63. At metaphase I average chromosome associations were 0.007IV+0.33III+6.12II. The bivalent frequency in the heptaploid hybrid (2n=7x=49, AABDGHH) was lower than expected; this was attributed to suppression of meiotic chromosome paired by *H. californicum* (HH).

167 BANDYOPADHYAY, S; DAS, JL; GHOSH, PD. 1988. **Tissue differentiation and buffer-soluble protein patterns in wheat and triticale**. *Current Science*, 57: 1, 20-23; 16 ref.

When buffer-soluble proteins of normal leaf, leaf derived callus and redifferentiated callus tissues of comparable ages of wheat and triticale were fractionated using the gel electrophoretic technique, remarkable variations in the number of protein bands, their position and intensities were observed. When the leaf tissues redifferentiated into callus in the presence of 2,4-D, the total number of bands decreased but some new characteristic bands appeared. The latter, however, disappeared with the appearance of some new characteristic bands when the calluses were redifferentiated into plantlets in the absence of 2,4-D. The omission of 2,4-D also resulted in the 'reappearance' of some bands originally found in the leaf tissues, showing a tendency

towards 'restoration of normalcy' in the redifferentiated tissues. It is suggested that 2,4-D induces morphogenetic changes through its effect on gene regulation. The persistence of a single band, though differing in Rm values, in all the 3 types of tissues in both the materials studied was also observed.

168 BAPAT, SA; RAWAL, SK; MASCARENHAS, AF. 1992. **Isozyme profiles during ontogeny of somatic embryos in wheat (*Triticum aestivum L.*).** *Plant Science Limerick*, 82: 2, 235-242; 16 ref.

The transition of immature embryos to the formation of embryogenic (E) or non-embryogenic (NE) callus and finally to germination of somatic embryos was associated with selective expression or repression of isoforms of peroxidase, esterase, glutamate dehydrogenase (GDH), hexokinase, phosphogluco-isomerase (PGI) [glucose-6-phosphate isomerase], 6-phosphogluconate dehydrogenase (6PgDH), glucose-6-phosphate dehydrogenase (G6PDH) and malate dehydrogenase (MDH). An isoperoxidase (Rm 0.32), isoesterases (Rm 0.93 and 0.80), an isohexokinase (Rm 0.17), an isoG6PDH (Rm 0.23) and isoMDHs (Rm 0.85, 0.82 and 0.15) were expressed during the early inductive phase of embryogenesis and in E callus. Isohexokinases (Rm 0.32 and 0.24) and an isoPGI (Rm 0.34) were expressed exclusively in the E calluses. Callus specific isoforms which were expressed in the E and NE calluses included 3 isoperoxidases (Rm 0.61, 0.58 and 0.47), 2 isoesterases (Rm 0.72 and 0.64), 2 isohexokinases (Rm 0.71 and 0.38), an isoPGI (Rm 0.16), an iso6PgDH (Rm 0.26) and isoG6PDHs (Rm 0.89, 0.74, 0.65, 0.54, 0.38, 0.29 and 0.10). Each developmental stage was associated with a definite isoenzyme profile.

169 BAPAT, SA; JOSHI, CP; MASCARENHAS, AF. 1988. **Occurrence and frequency of precocious germination of somatic embryos is a genotype-dependent phenomenon in wheat.** *Plant Cell Reports*, 7: 7, 538-541; 11 ref.

Immature embryos of 33 genotypes were cultured on medium containing 2,4-D. Precocious germination of the zygotic and somatic embryos occured simultaneously on the same medium, the frequency ranging from 0 to 88% and 0 to 84% for zygotic and somatic embryos, respectively. The genotypes NI5439 and NI5643 (which are characterized by a high tillering capacity) required total absence of hormone for shoot elongation although multiple shoot primordia were formed on auxin-containing medium. The majority of genotypes exhibiting precocious germination of zygotic embryos had high embryogenic potential. Most of the genotypes that showed precocious germination of somatic embryos exhibited a high frequency and a rapid rate of plantlet regeneration.

170 BEHL, RK; SAREEN, PK; SHARMA, DR. 1978. **Studies on early development of embryo and endosperm in triticale wheat crosses.** *All India Conf. of Cytology and Genetics*. (Hisar: 3rd: 1978 Oct). Haryana Agricultural University, Hisar.

171 BHAGWAT, SG; BHATIA, CR. 1988. **Variation in high molecular weight glutenin subunits of Indian wheat varieties and their Glu-1 quality scores.** *International wheat genetics symposium*. (Cambridge: 7th: 1988: July 13-19)/edited by TE Miller, RMD Koebner. Institute of Plant Science Research. p. 933-936; 13 ref.

High molecular weight glutenin subunits of 23 Indian varieties and breeding stocks were determined using SDS-PAGE. Subunits 1 and 2* of the A genome and 2 + 12 and 5 + 10 of the D genome predominated. The B genome subunits were identified as 7 + 8, 7 + 9 and 20. The subunits encoded by the A genome were absent in NI4, NG14-4-110 and Moti. Glu1 quality scores were estimated for each variety from the scores assigned to subunits by P. I. Payne et al. [see Journal of the Science of Food and Agriculture (1987) 40, 51-65]. Hira, Hy65, K68 and UP310, which are good for bread making, and C273, good for chapaties, were among those with high scores (9 or 10). Quality scores improved when the progeny of the best F2 plants were backcrossed to the F2 parent.

172 BHATTACHARYYA, RN; BASU, PS. 1989. **Effect of ethrel on kinetin-induced growth and IAA metabolism in wheat coleoptiles.** *Indian Journal of Plant Physiology*, 32: 4, 281-287; 18 ref.

Kinetin induced elongation of wheat coleoptile sections. Though the extent of elongation was less than with IAA, it was induced at much lower concn. The growth promoting property of kinetin was negated when the oxidation of endogenous IAA in the coleoptiles was interrupted by pretreatment with chlorogenic acid or ethylenediaminetetra-acetic acid (disodium salt). Growth promotion by kinetin was also inhibited when the coleoptiles were treated with sodium salt of diethyldithiocarbamic acid or reduced glutathione, which probably formed adducts with endogenous methylene oxindole, an oxidation product of IAA through oxindole pathway of IAA metabolism. The inhibition of growth of coleoptiles pretreated with chlorogenic acid was restored 67% after addition of ethrel(ethephon). It is suggested that when

the oxindole pathway was blocked, ethrel might increase (through an alternative pathway involving increased peroxidase activity) the level of endogenous Meox (methylene oxindole) sufficiently to promote growth. Subsequently, when the peroxidase activity was also inhibited with 2,2'-dipyridyl the kinetin induced growth of the coleoptiles was inhibited and could not be restored by ethrel.

173 BISWAS, SR; MISHRA, AK; NANDA, G. 1988. **Xylanase and beta-xylosidase production by *Aspergillus ochraceus* during growth on lignocelluloses**. *Biotechnology and Bioengineering*, 31:6, 613-616.

The utilization of some lignocellulosic materials by *Aspergillus ochraceus* for xylanase and beta-xylosidase production was studied. In order to avoid the use of purified xylan which increases the cost of enzyme production and limits the economic feasibility of the untilization of lignocellulosic materials, substrates such as wheat straw, wheat bran and sugarcane bagasse were used. Methods of obtaining opt. levels of xylanases were investigated.

174 CHAWLA, HS. 1988. **Isozyme modifications during morphogenesis of callus from barley and wheat**. *Plant Cell, Tissue and Organ Culture*, 12: 3, 299-304; 12 ref.

From studies (described) with 2 varieties of wheat and 2 of barley, it is concluded that esterase, peroxidase and acid phosphatase cannot be used as markers to distinguish between morphogenic and non-morphogenic calluses, since changes in isoenzyme patterns become apparent only after shoot and root initiation.

175 CHAWLA, HS. 1989. **Regeneration responses of callus from different explants and changes in isozymes during morphogenesis in wheat**. *Biologia Plantarum*, 31: 2, 121-125; 15 ref.

Immature embryo and root meristem explants were cultured on modified MS and Gamborg B5 medium. Morphogenetic callus was obtained from both types of explant. The frequency of shoot formation was 22-48% from embryo-derived callus, but only root development was induced in root meristem explants. An analysis of isoenzymes of esterase, peroxidase and acid phosphatase revealed the appearance of some conspicuous isoenzymes with shoot and/or root development from callus, suggesting the involvement of these isoenzymes in this development.

176 CHAWLA, HS; WENZEL, G. 1989. **Resistant wheat plants against *Helminthosporium sativum* from embryo derived callus cultures**. *Wheat Information Service*, No. 69: 8-12; 14 ref.

Embryo-derived calluses from the wheat cultivars Atys and Pitic 62 were grown on medium containing helminthosporal and victoxinine toxins from *H. sativum* [*Cochliobolus sativus*]. Some calluses resistant to the toxins were regenerated and 7 green plants insensitive to the pathogen were obtained.

177 CHOWDHURY, JB; MAHERCHANDANI, N; SHARMA, DR. 1978. **Studies on callus initiation, growth and differentiation in wheat (*T. aestivum*)**. *All India Conference of Cytology and Genetics*. (Haryana Agricultural University, Hisar: 1978: October).

178 CHOWDHURY, VK; MAHERCHANDANI, N; SHARMA, DR; JAIN, RK. 1980. **Effect of growth regulations on the activity of alpha amylase, peroxidase ad total soluble protein in cultured cells of wheat (*Triticum aestivum*)**. *Proc Natil. Symp. Plant Tissue Culture Genetic manipulations and somatic hybridization plant cells*. Bhaba Atomic Research Centre, Bombay, India. p. 417-425.

179 CHOWDHURY, VK; MEHERCHANDANI, N; SHARMA, DR; JAIN, RK. 1980. **Effects of growth regulators on respiratory enzymes in cultured cells of wheat**. *Inidan Journal Biochem. Biophys.* 17 (s): 9.

180 CHOWDHURY, VK; MAHERCHANDANI, N; SHARMA, DR; JAIN, RK. 1980. **Malate dehydrogenase and glutamate dehydrogenase activities in the callus culture of wheat (*Triticum aestivum L.*)**. *National Seminar on Genetics and Wheat Improvement*. (Haryana Agricultural University, Hisar: 1980: February). p. 204.

181 COHEN, JI. 1989. **Strengthening collaboration in biotechnology: international agricultural research and the private sector**. *Proceedings of a conference*. (Rosslyn, VA: 1988: April 17-21). Office of Agriculture, Bureau for Science and Technology, Agency for International Development, Washington, DC 20523-1809, USA. xii + 480 p.

A total of 34 papers given at the conference are presented under the 12 session headings as follows: (1) Building bridges of collaboration (including papers on the International Agricultural Research Centres, such as the CGIAR Centers, the public and private sectors in developing countries and the international seed companies); (2) National and regional biotechnology programs: needs and opportunities (including Thailand and CATIE

(Tropical Agriculture Research and Training Centre)); (3) Applications of plant cell and tissue culture for crop improvement (including cell genetics, the products of the DNA Plant Technology Corporation, micropropagation and cassava research at CIAT (International Center for Tropical Agriculture), the use of tissue culture in rice breeding at the International Rice Research Institute (IRRI), tissue culture for germplasm management and somaclonal variation); (4) Commercialization and research perspectives for vaccines (including the role of ILRAD and the private sector); (5) Molecular technologies for crop improvement: viral and pest management, molecular markers and recombinant DNA (including coverage of RFLPs); (6) Facilitation of wide crosses through biotechnology (includes consideration of ovule and embryo culture in *Arachis* and alien germplasm in wheat improvement); (7) Genetic resources: commercial and public initiatives linking conservation, evaluation and utilization (including the Latin American maize project, plant protection in developing countries and the plant genetic resources network in India); (8) New agendas for collaborative research and commercialization (including specific projects involving the International Fund for Agricultural Research and CIMMYT (International Maize and Wheat Improvement Center)); (9) International funding agency support of biotechnology research (including the Rockefeller Foundation's rice programme and USAID's experiences in India); (10) Biosafety concerns regarding agricultural research; (11) Biotechnology-based animal and plant diagnostic tests (including DNA and immunology probes); and (12) Commercialization, patents and technology transfer (including Crop Genetics' experiences). Finally, there are brief workshop reports on biosafety in agricultural research, application of diagnostics for plant and animal pathogens, genetic resources/wide crosses, molecular technologies, plant cell and tissue culture, and vaccine development. The conference is based on the assumption that collaboration with the private sector is a good thing for international agricultural research and developing countries, and arguments against this idea are not considered in any depth. However, some interesting points are raised in the workshops and valuable overviews of research in progress are given.

182 DAS, G; MANDI, S SEN. 1992. **Triphenyl tetrazolium chloride staining pattern of differentially aged wheat seed embryos.** *Proceedings of the International Seed Testing Association*. Seed Science and Technology (Switzerland), 20: 3, 367-373.

183 DISA, S; GUPTA, A; MUKHERJEE, S; SOPORY, SK. 1985. **Requirement for a long lag period for the induction of nitrate reductase in wheat (*Triticum aestivum*) embryos during germination**. *New Phytologist*, 99: 1, 71-80; 28 ref.

Induction of nitrate reductase (NR) in embryos of wheat cv. 2009 required 20 h incubation with KNO3 at 25°C during the early stages of seed germination under continuous white light. The effects of cyclohexamide, Mo, tungstate, actinomycin-D, 6-methyl purine and cordycepin on NR induction are presented. It was concluded that this lag phase in development of NR activity was not due to non-availability of nitrate, presence of NR inactivating factor or synthesis of inactive NR, as at the onset of the inducible phase NR was synthesized de novo independent of fresh m-RNA synthesis, and protein synthesis during the lag phase was essential for subsequent induction of NR in the inducible phase.

184 EAPEN, S; RAO, PS. 1985. **Factors controlling pollen embryogenesis in triticale and wheat**. *Proceedings of Indian National Science Academy, Part B: Biological Sciences*, 51: 3, 353-359; 27 ref.

Anthers from one cultivar of triticale, 5 of *Triticum aestivum* and 3 of *T. turgidum subsp. durum* [*T. durum*] were cultured on different media. Embryoids were obtained from several cultivars, but only *T. aestivum cv. UP310* gave rise to plantlets. In *triticale cv. 6T209*, which was studied in most detail, embryogenesis was highest on potato II medium supplemented with proline. Culture of floating anthers was superior to culture on semisolid medium for inducing embryogenesis.

185 EAPEN, S; RAO, PS. 1985. **Factors controlling callus initiation, growth and plant regeneration in breadwheat (*Triticum aestivum L.*)**. *Proceedings of the Indian Academy of Sciences, Plant Sciences*, 94: 1, 33-40; 27 ref.

Callus cultures were initiated from immature embryos and grains. The frequency and intensity of callus development were greatest when embryos were placed with the embryonal axis in contact with the medium and the scutellum facing up. Callusing frequency was enhanced when embryos were cut in half longitudinally and cultured. In embryo-derived callus of the variety N1-4, shoot buds and roots differentiated de novo on a Murashige & Skoog basal medium without growth regulators. Embryo-derived callus of Kalyan Sona required zeatin and IAA for regeneration.

186 EAPEN, S; RAO, PS. 1984. **Factors controlling callus proliferation, growth and regeneration from immature embryos of rye and triticale**. *Proceedings of the Indian National Science Academy, Biological Sciences*, 50: 4, 431-437; 22 ref.

Callus cultures capable of differentiation were initiated from immature embryos of rye and triticale. Frequency and intensity of callus development were opt. in embryos cultured with scutellum facing up and in those in which the embryos were split longitudinally into 2 halves. Agar-solidified medium produced a higher frequency of embryo response compared with stationary liquid cultures. Among the different C sources, glucose and sucrose favoured good callus growth. Addition of yeast extract and malt extract was either without effect or was inhibitory for callus growth. Histological examination of regenerating callus cultures showed de novo development of shoot buds. No evidence for somatic embryogenesis was observed.

187 EAPEN, S; SUSEELAN, KN; BHAGWAT, SG; RAO, PS; BHATIA, CR. 1985. **Grain yield and yield components of regenerated wheat plants in SC-4 generation**. *Proceedings of Indian National Science Academy, Part B: Biological Sciences*, 51: 5, 627-632; 14 ref.

Plants were regenerated from callus cultures initiated from mature embryo explants of Kalyan Sona and NI4. The regenerated (SC1) plants of NI4 showed chlorophyll variants including albina and striata; no such variants occurred in Kalyan Sona. Progenies of NI4 segregated for chlorophyll variants up to the SC3. The highest yielding SC3 plants derived from each of the original SC1 plants were selected and their progenies evaluated for grain yield and various yield components and quality traits in replicated field experiments. All the 18 regenerated lines of Kalyan Sona were statistically similar to the control in grain yield. Most of the yield components, gliadins and high molecular weight glutenins were comparable to those of the parent. In NI4, which showed the greater phenotypic variability, 6 out of 12 regenerated lines were equal in grain yield. The results are taken to indicate that some of the unwanted genetic alterations induced by in vitro culture are partly eliminated by subsequent cycles of sexual reproduction and can be reduced further by conventional selection of parental and higher yielding single plants to recover lines equal in productivity to the original cultivar.

188 EAPEN, S; RAO, PS. 1985. **Plant regeneration from immature inflorescence callus cultures of wheat, rye and triticale**. *Euphytica*, 34: 1, 153-159; 21 ref.

Callus cultures were initiated from inflorescence explants (1 cm pieces) of *Triticum aestivum cv. Kalyan Sona*, rye, and *triticale cv. 6T209* on Murashige & Skoog medium supplemented with 2,4-D and either coconut water or BA. When the cultures were tranferred to medium containing NAA or IAA, shoot buds and embryoids were produced. Plants were regenerated and transferred to the field. They were diploid, but were shorter, produced fewer tillers and had lower fertility than the control.

189 FAROOQ, S; IQBAL, N; SHAH, TM. 1990. **Promotion of homoeologous chromosome pairing in hybrids of *Triticum aestivum* X *Aegilops variabilis***. *Genome*, 33: 6, 825-828; 21 ref.

T. aestivum variety Lu26 and the ph1b mutant of cv. Chinese Spring were crossed with accessions A, B and E of *A. variabilis*. Significant differences were found in the amount of homoeologous chromosome pairing at meiotic metaphase I. Hybrids between Lu26 and accessions A and B showed very little pairing, as indicated by the chiasma frequency of 1.0 and 1.5 per cell, respectively. Hybrids between Lu26 and accession E, on the other hand, showed significantly increased homoeologous pairing (mean chiasma frequency, 12.6/cell); similar levels of pairing were found in hybrids of ph1b Chinese Spring with accessions A and B. However, when the ph1b mutant was hybridized with accession E, the level of chromosome pairing increased significantly (mean chiasma frequency, 17.52/cell), indicating the presence of pairing promoter gene(s) in accession E, which are epistatic to the wheat Ph1 allele and positively interact with its mutant form to further increase the ph1b ceiling to homoeologous pairing in wheat.

190 GAUR, PM; SINGH, CB; GAUR, VK. 1983. **Relationship between meiotic instability and fertility in F3 generations of triticale X wheat crosses**. *Cereal Research Communications*, 11: 3/4, 209-212; 10 ref.

Analysis of data from the F3 of crosses between two hexaploid triticales (female) and three wheats (male) showed that pollen fertility, floret fertility and meiotic instability were independent of each other. In improving secondary triticales, selection for high floret fertility is recommended.

191 GILL, KS; SANDHA, GS; DHINDSA, GS. 1991. **Germplasm evaluation and utilization in spring triticale**. *International Triticale* Symposium. (Mexico: 2nd: 1991). Brazilian Agricultural Research Enterprise, Passo Fundo (Brazil) National Wheat Research Center, Mexico, D.F. p. 30-31.

Spring triticale germplasm consisting of 485 genetic stocks obtained from India, CIMMYT (Mexico), USA, USSR, Canada, Hungary, Australia, etc., was statistically analyzed for length and width of flag leaf, length of flag leaf sheath, length of peduncle, length of spike, spikelets per spike and grains per spike. Extensive variability was observed for all characters studied. Minimum and maximum values observed were: 14.8-33.9 cm for length of flag leaf, 1.2-2.4 cm for width of flag leaf, 44.8-172.4 cm for plant height, 14.8-29.3 cm for sheath of flag leaf, 5.0-39.9 cm for length of peduncle, 6.1-27.2 cm for length of spike, 14- 15 spikelets per spike, 16-130 grains per spike and 2.6-8.4 g weight of grains per spike. Extensive variability was present for many other plant and grain quality characters which are under further study. Based on these and other investigations and visual observations, the germplasm was classified into a number of groups, viz. good agronomic, amber color, hard grain, dwarf, long ear, primary hexaploid and octoploid, released cultivars from different countries, glume color, thick ear, branched ear, awn characters, new bulks, etc., to facilitate their use in crossing programs. This approach, combined with rye, winter triticale, improved bread wheat and durum wheat cultivars grown in adjacent blocks, considerably facilitates their use in hybridization work. The need to further strengthen germplasm from indigenous and exotic sources particularly for amber-colored, hard, plump, attractive grain, high and stable yield, high harvest index and multiple resistance to different diseases, high nutritionally and good quality for different food products and as feed and forage has been stressed.

192 GILL, RS; DHALIWAL, HS; MULTANI, DS. 1988. **Synthesis and evaluation of *Triticum durum-T. monococcum* amphiploids**. *Theoretical and Applied Genetics*, 75: 6, 912-916; 18 ref.

Nine amphiploids (genomes AABBAmAm) were synthesized by chromosome doubling of sterile triploid F1 hybrids involving 9 *T. durum* (AABB) cultivars and a *T. monococcum* (AmAm) line. The triploid F1 hybrids had a range of 4-7 bivalents and 7-13 univalents per PMC. The synthetic amphiploids, however, showed a high degree of preferential pairing of chromosomes of the A genomes of the diploid and tetraploid wheat parents. The amphiploids were meiotically stable and fully fertile. Superiority of 4 amphiploids to durum and bread wheat cultivars for tiller number per plant, 100-grain weight, protein content and resistance to Karnal bunt [*Tilletia indica*] suggested that they could either be commercially exploited after further improvement or used to introgress desirable genes into wheat cultivars.

193 GUPTA, PK; FEDAK, G. 1988. **Meiotic analysis of callus regenerated plants from a cross between *Triticum aestivum* (2n = 42) and Agropyron elongatum (2n = 70)**. *International Wheat Genetics Symposium*. (Cambridge: 7th: 1988: July 13-19)/edited by TE Miller, RMD Koebner. Institute of Plant Science Research. p. 293-296; 13 ref.

Plants of *T. aestivum* X *A. elongatum* [*Elymus elongatus*] (2n = 56) were regenerated from callus induced on immature inflorescences cultured on Kao medium supplemented with 5 mg 2,4-D/litre. The regenerants showed more bivalents, trivalents and quadrivalents than a control hybrid that had not been tissue cultured.

194 GUPTA, PK; FEDAK, G. 1986. **Partial amphiploids from wheat (*Triticum aestivum*) X rye (*Secale cereale*) crosses**. *Canadian Journal of Genetics and Cytology*, 28: 4, 624-627; 5 ref.

Two groups of 3-way hybrids were produced by crossing F1 hybrids of the rye crosses Petkus X Prolific and Prolific X Puma with the wheat cultivar Chinese Spring. In 3 families from the first group, 5 partial amphiploids with chromosome numbers of 2n = 35, 36, 36, 38 and 41 were identified. The mean frequencies of bivalents in meiotic cells of these hybrids were roughly equal to the number of chromosomes in excess of the expected number of 2n = 28. The origin of these partial amphiploids is attributed to duplication of a portion of the wheat complement after fertilization.

195 GUPTA, SD; GHOSH, PD. 1983. **Chromosome analysis in callus culture of *Triticum aestivum***. *Nucleus, India*, 26: 1, 16-18; 12 ref.

Root callus tissues from Sonalika cultured on Murashige and Skoog medium containing 0.5 mg/l 2,4-D were examined at 30, 60 and 90 days. Cytological abnormalities, such as high and low chromosome number, fragmentation, sticky bridges and multipolarity, were found at all stages; they were most common in aneuploid cells and frequencies increased with time.

196 GUPTA, SD; GHOSH, PD. 1983. **Migration of nuclear material in callus cultures of *Triticum dicoccum* Schulb**. *Currrent Science*, 52: 8, 369-370; 7 ref.

Examination of *T. dicoccum* root callus showed a marked variation in chromosome numbers and most of the cell population was made up of aneuploid cells. A spontaneous movement of nuclear material from 1 cell to another through a cytoplasmic channel in the cell wall was observed. In some cases micronuclei were formed; most of them are believed to degenerate in the cytoplasm. Another peculiarity observed was that successive

migration of nuclear material was preceded by the formation of a bud-like protuberance on the cell wall. The migration of nuclear material can be considered as another possible mechanism for the development of aneuploid cells besides that of chromosome lagging at anaphase and multipolar spindle formation.

197 GUPTA, SD; AHMED, R; GHOSH, PD; ROY, DGD; GUPTA, SD; ROY, DGD; AHMED, R. 1987. **Nuclear volume and DNA contents in in vivo and in vitro conditions in *Triticum aestivum L.*** *Indian Journal of Experimental Biology*, 25: 4, 217-219; 15 ref.

A strong correlation was observed between nuclear volume and nuclear DNA content in both root tip cells and root-derived callus cells. Callus cells had a higher DNA content than root tip cells and this increase was thought to have occurred during in vitro culture. The base composition of the DNA of the 2 types of cell was the same. A comparison of renaturation kinetics indicated that the number of copies of repeated DNA sequences was increased by in vitro culture. The increase was attributed to endoreduplication.

198 GUPTA, SD; AHMED, R; GUPTA, SD; AHMED, R. 1987. **Role of inoculum weight on tissue growth and plantlet regeneration in *Triticum aestivum L.*** *Indian J. of Exper. Biology*, 25: 4, 235-237; 12 ref.

The weight of mesocotyl segments significantly affected subsequent callus growth and plantlet regeneration. Small explants (60.4 mg on average) grew faster on culture media than larger ones (85.2 or 110.3 mg), but only the larger explants produced shoots in regeneration medium.

199 GUPTA, SD; AHMED, R. 1986. **Structural alterations of chromosomes during callus culture of *Triticum aestivum L.*** *Cereal Research Communications*, 14: 1, 33-40; 39 ref.

Structural changes observed in callus (30-90 days old) of cv. Sonalika included deletions, translocations and the formation of dicentric and acentric fragments; their frequency increased with culture age. A variant karyotype consisting of 40 chromosomes, including 2 acrocentrics, was observed in 30-day-old callus. Giemsa banding studies suggested that the acrocentrics originated from metacentric or submetacentric chromosomes by the deletion of one arm, and that chromosome breakage in culture occurred in the interstitial and not in the centromeric region.

200 HOSSAIN, MT. 1995. **Plant regeneration in improved triticale lines with higher protein content.** *Annual Plant Tissue Culture Conference.* (Dhaka University, Dept. of Botany: 1995: March 19).

201 HOSSAIN, T; ISLAM, AS. 1993. **Improvement of protein content in four tissue-cultured derived *Triticale* strains.** *International Plant Tissue Culture Conference.* (Dhaka Univ., Dept. of Botany: December 19-21)

202 HUANG, CY; GRAHAM, RD. 1990. **Resistance of wheat genotypes to boron toxicity is expressed at the cellular level.** *Plant and Soil*, 126: 2, 295-300; 10 ref.

The effects of toxic boron (B) concentrations on the growth of 7 genotypes at organ level and cellular level were investigated using excised root culture techniques. At the organ level, the genotypes differed in root elongation and lateral root development in response to toxic B concentration. Genotypes classified as resistant from field studies had longer root axes and more lateral roots than sensitive or moderately sensitive genotypes, but there was no difference in axis elongation between sensitive and moderately sensitive genotypes. At the cellular level, callus production of root explants among genotypes in resistance to toxic B concentrations: resistant genotypes could produce more callus than sensitive or moderately sensitive genotypes. The results suggest that differences among genotypes in resistance to toxic B concentrations may be related to cell membrane permeability to B since they were also expressed in undifferentiated callus cells. India 126 was the most tolerant genotype.

203 HUSSAIN, R. 1991. **Chemogenetic basis for stress tolerance in wheat (*Triticum aestivum L.*).** UAF, Faisalabad (Pakistan), 106 p.

204 INAGAKI, MN; TAHIR, M. 1990. **Effect of silver nitrate on callus induction and plant regeneration in wheat.** *Rachis*, 9: 2, 19-20; 7 ref.

Immature embryos of varieties Local White from Pakistan and Roshan and Sabalan from Iran were cultured on MS media with 10 mg AgNO3/litre. The control medium was supplemented with 2 mg 2,4-D/litre instead. Callus was produced in all cases. Embryoids were produced at only low frequencies on media without AgNO3 (not at all in Local White) but at higher frequencies on AgNo3 media, particularly in Sabalan. Plantlet regeneration followed a similar trend. Best response was from Sabalan and worst from Local White.

205 JAGTAP, JG. 1983. **Production of secondary triticale by triple cross**. *Indian Journal of Agricultural Sciences*, 53: 7, 596-598; 4 ref.

Triticum aestivum cv. Hy65 was crossed with diploid Indore Rye and the resulting male-sterile hybrids were crossed with the high-yielding CIMMYT triticale strains AT(I)21 and AT(I)29. Comparative data are tabulated on plant height, yield and four yield components.

206 JOSHI, AK; SINGH, BD; SINGH, F. 1992. **A comparision of tall and dwarf segregants from some wheat crosses for yield and yield traits**. *Crop Improvement*, 19: 1, 23-28.

207 KAHLON, SS. 1986. **SCP production by *Chaetomium* cellulolyticum on treated waste cellulose**. *Journal of Research, Punjab Agricultural University*, 23: 2, 330-335; 19 ref.

The opt. conditions for converting wheat straw into single cell protein by *C. cellulolyticum* [*C. virescens*] are described. CMCase production had no direct bearing on ultimate protein production. Max. protein was produced with a 0.25 g NaOH/g pretreatment at pH 5 and 37-40°C with supplemented N as NaNO3 at 400 mg N/litre.

208 KARIM, MA; SINGH, MP. 1988. **Effects of additional alien chromosomes on morphological traits and seed fertility in cytoplasmic male sterile wheats**. *Cereal Research Communications*, 16: 3-4, 211-217; 10 ref.

Aegilops comosa cytoplasm and chromosomes were introduced into 15 hexaploid wheats by repeated backcrossing to alloplasmic lines. In some cases one of 3 *A. comosa* chromosomes was preferentially transmitted with the *A. comosa* cytoplasm irrespective of the wheat cultivar involved. In some male-sterile lines, the additional chromosomes affected plant morphology, maturity and grain fertility in the F1 and backcross generations.

209 KARIM, MA; SINGH, MP. 1984. **Studies on fertility restoration in male sterile wheats derived from *Aegilops comosa* cytoplasm**. *Wheat Information Service*, No. 58: 9-11; 10 ref.

Lines of the wheat variety Chinese Spring with *A. comosa* cytoplasm were used as cytoplasmic donors for the production of male-sterile lines in backcrosses with 24 wheat varieties. In the BC2, crosses with Lal Bahadur, Ridley and HD1944 showed pollen fertilities of 91%, 32% and 19%, respectively, and selfed grain sets of 41%, 27% and 22%, respectively, indicating that these three varieties carry fertility-restoring genes. These three BC2 lines each carried a different *A. comosa* chromosome in addition to the cytoplasm. Female fertility was normal in all the crosses. Grain set under natural cross pollination was highest in the BC2 with Kharchia (68%), the BC1 with Mukta (65%) and the F1 with Kharchia (34%).

210 KAZI, AM; KUILE, NT; NABORS, M. 1993. **Potential of tissue culture applications in some triticeae via callus induced variation, alien introgression and amphiploid production**. *Annals of Biology*, 9: 1,1-15.

211 KHANNA, VK. 1990. **Germination, pollen fertility and crossability between triticale and wheat and reversion patterns in early segregating generations**. *Cereal Research Communications*, 18: 4, 359-362; 8 ref.

Five strains of hexaploid triticale, 5 cultivars of hexaploid wheat and a range of crosses among them were studied. Small grains showed the highest and large grains the lowest emergence capacity. Pollen sterility was greatest in triticales. When triticale was used as the female parent in crosses with wheat, grain set was low but germination of the grain was good, whereas in the reciprocal crosses grain set was high but no grain germinated. Useful transgressive segregants were observed in B1 (F1 X triticale), B2 (F1 X wheat) and F2 generations.

212 KHATOON, K. 1985. **Isolation and yield of protoplasts from different tissues of *Triticum aestivum* in sterile culture**. *Pakistan Journal of Botany*, 17: 2, 205-213; 21 ref.

Protoplasts from leaves and root tips excised from young seedlings and calluses induced from germinated seeds using 5 mg 2,4-D/litre at pH 5.6 were isolated in a digestion mixture containing 2.5% Macerozyme, 2.5% cellulase Onozuka-R-10 and 1% hemicellulase in 0.7% mannitol at pH 5.6 after 6 h of incubation. Mesophyll of young leaves yielded the highest amount of protoplasts and was considered a useful source of plant material. Excised seedling roots were a poor source of protoplasts.

213 LAGUDAH, ES; APPELS, R; MCNEIL, D. 1991. **The Nor-D3 locus of *Triticum tauschii*: natural variation and genetic linkage to markers in chromosome 5**. *Genome*, 34: 3, 387-395; 48 ref.

Variation in the intergenic spacer region of the rRNA genes (located at the Nor (nucleolus organizer) locus) was assayed in a collection of 411 accessions of *T.*

tauschii [*Aegilops squarrosa*] from Turkey, USSR, Iran, Afghanistan, Pakistan and China. Twenty rDNA genotypes were identified and it was demonstrated that *T. tauschii* accessions from the USSR and Iran have the highest diversity at the Nor locus. At least 4 of the rDNA genotypes proved to be alleles of a single major locus, in segregating F2 progeny analyses. The TaqI restriction fragment associated with rDNA genotype 7 was shown to be the same as the Nor-D3a allele present in *T. aestivum* (based on chromosome location and length of the intergenic spacer region). This genotype was significantly associated with *T. tauschii subsp. strangulata*, previously argued to be the donor of the D genome to hexaploid wheat. The Nor locus showed a high level of recombination with the 5SDna-2 locus, which was also located on chromosome 5D. The Nor locus is placed distal to the 5SDna-2 locus but proximal to the grain softness protein gene (XGsp) on the short arm of chromosome 5D.

214 LAKHANI, S; THIRU, AN; SACHAR, RC. 1983. **Synthesis of poly(A) polymerase from conserved messenger RNA in germinating excised embryos of wheat**. *Phytochemistry*, 22: 7, 1561-1566; 43 ref.

A 3.5- to 6.0-fold stimulation of poly(A) polymerase activity was observed in excised wheat embryos germinated for 48 h. Addition of primer RNA to the enzyme assay mixture was necessary for the incorporation of 3H-AMP into the acid-precipitable polyadenylate product. Administration of 6 amino acid analogues (1 mm each) or cycloheximide (10 μg/ml) to the germinating embryos resulted in 77-82% inhibition of poly(A) polymerase activity. The inhibitory response, elicited by the analogues, was substantially counteracted by the simultaneous addition of the corresponding 6 amino acids (2 mm each). This indicated that de novo protein synthesis was necessary for the enhancement of poly(A) polymerase activity. *Cordycepin*, a potent inhibitor of transcription, failed to block poly(A) polymerase activity; instead, the drug invariably brought about a significant stimulation (c. 1.7- to 4.0-fold) of the enzyme activity. *Cordycepin*, however, inhibited acid phosphatase activity by 77% in germinating wheat embryos. Actinomycin D also failed to inhibit poly(A) polymerase activity in germinating wheat embryos. The lack of inhibition of poly(A) polymerase by transcriptional inhibitors during early germination suggested that the enzyme was translated from its conserved mRNA, already stored in the dry wheat embryos.

215 LIPTON, M; LONGHURST, R. 1989. **New seeds and poor people**. London: Unwin Hyman, 464 p.

Modern varieties (MVs) of cereals, developed through plant genetics, currently add at least 50 Mt each year to Third World grain output. India, desperate for imports during 1965-67, now exports wheat in normal years. Yet most of Africa grows few or no MVs. In Africa and South Asia, poverty continues to increase. Evidence from plant breeding, economics, and nutrition science is used to pinpoint what has been achieved, what has gone wrong, and what to do next. The technical features of the MVs mean more employment, cheaper food and less risk for small farmers. Yet the gains bring new problems. By reducing crop diversity, successful but similar MVs increase the danger from pests. In areas unsuited to MVs, farmers often cannot compete. Workers are displaced as MV incomes help farmers to obtain weedicides or threshers. MVs may enlarge cereal stocks, yet the hungry are too poor to buy. Meanwhile, some researchers fine-tune grain quality, rather than increase the yield, robustness, or regional spread of MVs. Through it all, rural population, and labour supply continue to grow. Technical breakthroughs alone will not solve deep-rooted social problems. Only new policies and new research priorities, both agrotechnical and socioeconomic, will increase the choices, assets, and power of the rural poor.

216 MADYASTHA, KM; GANGULI, AR; KUBAIR, VG; KOWSER, N; VIDYA, D. 1987. **Extracellular invertase from *Aspergillus athecius*: isolation and immobilization**. *Biotechnology Letters*, 9: 8, 555-560; 12 ref.

This fungus isolated from soil produced large amounts of extracellular invertase when grown on moistened wheat bran. Most of the invertase from the mouldy bran was easily extracted by low ionic strength buffer (0.005 M, pH 5.7). The crude invertase immobilized on DEAE cellulose showed not only increased activity ($\approx$45%) but also greater thermal and storage stability than the free enzyme. The free and the bound enzyme showed a temp. opt. of 50-55°C and pH opt. of 5.7 and 4.8 respectively. The Km app. of the bound enzyme was lower than that of the free enzyme.

217 MALHOTRA, A; RANA, RS; SHARMA, DR; CHOWDHURY, JB. 1986. **Salinity stress response of plants and calli in wheat**. *Current Science*, 55: 22, 1133-1135; 11 ref.

Plants of varieties HD4502 and C306 were raised in pots of saline soil and evaluated for plant height, number of productive tillers/plant, ear length, 100-grain weight and grain yield/plant. In all, except 100-grain weight, C306 was superior to HD4502 under both saline

and non-saline (control) conditions. Reductions in these growth and yield parameters caused by NaCl stress were lower in C306 than in HD4502. Calluses derived from the embryonic axes of seedlings of both varieties were cultured on media supplemented with NaCl at concentrations of 0.5 and 1.0%. In both cases, callus increased with the decrease of NaCl conc. At both concentrations and at 30, 45 and 60 days of growth, calluses of C306 showed higher NaCl tolerance than those of HD4502.

218 MARGIOTTA, B; LAFIANDRA, D; TOMASSINI, C; PERINO, P; PORCEDDU, E. 1988. **Variation in high molecular weight glutenin subunits in a hexaploid wheat collection from Nepal**. *International Wheat Genetics Symposium*. (Cambridge:7th: 1988: July 13-19)/edited by TE Miller, RMD Koebner. Institute of Plant Science Research. p. 975-980; 13 ref.

SDS-PAGE was used to study glutenin subunits in 57 wheats collected in different river valleys and at various altitudes in Nepal. A null allele at the Glu-A1 locus was common in all populations and its frequency reached 100% in 5 high-altitude populations in 3 valleys, although no direct correlation between altitude and frequency was found. The 17 + 18 allele at the Glu-B1 locus was common in most populations, while the 7+8 was only present in 2 samples collected at high altitude. The 2 + 12 and 5 + 10 alleles at the Glu-D1 locus were uniformly distributed. Clusters of populations based on Nei distances did not show any relation to geography, suggesting that human factors may have been at least as important as ecological factors.

219 MOHMAND, AS; NABORS, MW. 1991. **Induced in vitro variability for drought tolerance in wheat**. *Pakistan J. of Agricultural Res.*, 12: 2, 87-94.

220 NEERAJ; KHANNA, VK. 1992. **Studies on pollen germination, pollen tube growth and seed set in reciprocal wheat-barley crosses**. *Wheat Information Service*, No. 74: 28-32; 17 ref.

Pollen germination and pollen tube behaviour is reported in crosses involving *Triticum aestivum cv. UP2121, T. durum cv. PBW34* and the diploid huskless barley cultivars Karan 4 and Karan 265. Gibberellic acid, IAA and kinetin were sprayed on florets 24 h after pollination at a concentration of 75 p.p.m. Pollen germinated 5 minutes after pollination in UP2121 X Karan 4 and UP2121 X Karan 265. After 24 h the highest pollen germination percentages were in UP2121 X Karan 4 (57.1%). Seed set ranged from 4.0% (PBW34 X Karan 4 and PBW34 X Karan 265) to 74.7% in Karan 4 X PBW34. Increased seed set was noted after treatment with all 3 growth regulators in all crosses except Karan 4 X PBW34 and Karan 265 X UP2121. Kinetin was most effective in increasing seed set, affecting 8 out of 12 crosses.

221 PADMAJA, G; REDDY, VD; REDDY, GM. 1993. **Somaclonal variation from regenerants of mature embryo calli of triticale**. *Indian Journal of Experimental Biology*, 31: 3, 238-241.

222 PALADHI, MM; BHOWAL, JG. 1986. **Association of ear shape with plant height and ear size in crosses of *Triticum sphaerococcum* and *T. compactum* with cultivars of *T. aestivum***. *Indian Journal of Agricultural Sciences*, 56: 3, 157-160; 2 ref.

Analysis of F2 data on ear shape and plant height from crosses involving *T. sphaerococcum* and *T. compactum* with *T. aestivum* cultivars NP846, C306 and C591 revealed the following: (1) association of elliptical ear and semidwarf stature, of fusiform ear and tall stature, of elliptical ear and short ear and of fusiform ear and long ear in the crosses of *T. sphaerococcum*; (2) independence of clavate ear and semidwarf stature and of fusiform ear and tall stature in the crosses of *T. compactum*; and (3) independence of clavate ear and short ear and of fusiform ear and long ear in 2 *T. compactum* crosses but association in *T. compactum* X *T. aestivum cv. NP846*. However, in those instances where traits were associated some recombination occurred. The data are considered to indicate that it should be possible to incorporate desirable traits from *T. compactum* and *T. sphaerococcum* into *T. aestivum* in order to combat moisture stress and to help broaden the genetic base of semidwarf stature.

223 PANDEY, HN; SINGH, D. 1992. **Exploitation of AAGG genomes of *Triticum timopheevii (Zhuk.)***. *Wheat Information Service*, No. 74: 6-8.

Two tall *Triticum durum* cultivars, NI146 and MACS9, were crossed as female parents with a *T. timopheevii* strain. The F1 hybrids were backcrossed to their tall parents, then the B1F1 plants were crossed with semidwarf *T. durum* cultivars, Raj 1555 and DWL 5023. After the 9th generation derivatives were evaluated for 8 yield components. Seedling characteristics were assessed in lines B138, B139, B174, B180, *T. timopheevii* and PBW34 (*T. durum*). Under field conditions 2 derivatives outyielded the control, PBW34, by 14.4-26%. Increased root number with reduced stem height in the same 2 entries appeared to result in good lodging resistance.

224 RAFIQ, M. 1991. **Combining ability in wheat (*Triticum aestivum L.*) from line X tester analysis.** UAF, Faisalabad (Pakistan), 98 p.

225 RAINA, SK. 1984. **Crossability and in vitro development of hybrid embryos of *Triticum durum* X *Secale cereale*.** *Indian Journal of Genetics and Plant Breeding*, 44: 3, 429-437; 5 ref.

Crosses between 4 *T. durum* varieties and Assam (AR) and Russian rye (RR) did not set grain but some of the embryos (5.6%) isolated from occasional shrivelled caryopses of the crosses involving the wheat Raj 911 germinated in vitro, on Taira & Larter's modified Norstog's medium. The percentage of embryos observed was least (1.94%) in HD4545 X AR and greatest (20.62%) in JNK184 X AR. The presence of endosperm appeared to inhibit the development of hybrid embryos. The maximum number of viable hybrid seedlings was obtained from relatively normal hybrid embryos (about half the size of selfed wheat embryos) excised 20-22 days after pollination and cultured. Embryos from crosses involving AR showed a higher frequency of seedling development than those involving RR. Genotype and the temperature at which the parental lines were grown appeared to be important for development and differentiation of hybrid embryos in vivo and for germination in vitro.

226 RAJPER, MM; MALIK, AJ; ANSARI, BA. 1990. **Variability and heritability of yield and yield related characters in wheat (*Triticum aestivum L.*).** *Pakistan Journal of Agriculture, Agricultural Engineering Veterinary Sciences*, 6: 1-2, 49-54.

227 RAJYALAKSHMI, K; DHIR, SK; MAHESHWARI, N; MAHESHWARI, SC. 1988. **Callusing and regeneration of plantlets via somatic embryogenesis from inflorescence cultures of *Triticum aestivum L.*; role of genotype and long-term retention of morphogenic potential.** *Plant Breeding*, 101: 1, 80-85; 18 ref.

A high frequency of regeneration of plantlets via somatic embryogenesis was achieved from callus derived from immature inflorescence explants of cv. Sonalika. The explants were cultured on Murashige & Skoog medium supplemented with 2,4-D, casein hydrolysate and coconut milk. A large number of embryoids germinated to form plantlets on the medium when 2,4-D was omitted or provided at low concentration. Plantlets were transferred to soil under natural environmental conditions and were shown to have the normal chromosome number of 2n = 6x = 42. Experiments with 19 other varieties showed a marked effect of genotype both on initiation of callusing and on regeneration. Sonalika was the most responsive among varieties tested. With callus of Sonalika, an investigation on long-term retention of regenerative potential showed that, during culture for about 12 months, the morphogenic potential gradually diminished and was finally lost, but the regeneration potential could be restored by subculturing at very short intervals.

228 RANDHAWA, AS; DHALIWAL, HS; SHARMA, SK. 1991. **Meiotic and breeding behaviour of interspecific hybrids of *Triticum aestivum* and *Triticum durum*.** *Crop Improvement*, 18: 1, 63-67.

229 RANDHAWA, AS; SHARMA, SK; DHALIWAL, HS. 1992. **Rust resistant lines of wheat derived from different crosses involving cultivar C-306.** *Indian Journal of Genetics and Plant Breeding*, 52: 2, 174-177.

230 RAO, VSP; TAWARE, SP; PATIL, VP. 1984. **Identification of dwarfing genes in three wheat varieties.** *Biovigyanam*, 10: 1, 87-88; 2 ref.

Data are presented from crosses of the dwarf Indian varieties DWR39, HD2278 and WL2265 to the tall variety NP852-12A (dwarfing gene genotype rht1 rht2) and the testers Kalyan Sona (Rht1 rht2), Sonora 64 and Pitic 62 (both rht1 Rht2) which show that all three Indian varieties have Rht1.

231 RATHORE, RKS; CHAUAN, SS. 1986. **Heterotic studies in spring wheat.** *Madras Agricultural Journal*, 73: 8, 425-429; 12 ref.

Two *Triticum timopheevii*-derived cytoplasmically male sterile lines were crossed with 12 M4 mutants derived from 4 restorer lines. Heterosis over the mean parental value and the better parent was significant for yield and 4 yield components in many cases. The greatest heterosis ws found for 100-grain weight, followed by yield/plant. Of the 24 F1 hybrids, 14 showed significant positive heterosis over the mean parental value for yield. It is suggested that heterosis was limited in some cases by the male sterility restoration system used.

232 RAUT, VM; PATIL, VP; DEODIKAR, GB. 1984. **Genetic studies in tetraploid wheats. VII. Inheritance of seedling resistance against stem rust races.** *Biovigyanam*, 10: 2, 101-106; 13 ref.

Analysis of data on resistance to 6 races of *Puccinia graminis f. sp. tritici* in the F1, F2 and BC1 generations

of 5 crosses involving 5 varieties of *Triticum durum* and 2 of *T. carthlicum* revealed that resistance was dominant to susceptibility and controlled by 1-3 genes (varying between varieties and races). Duplicate and complementary interactions were observed. MACS68 (an interspecific hybrid) and *T. carthlicum cv. 1582* are recommended for use in resistance breeding.

233 REDDY, VD; REDDY, GM. 1983. **Efficiency of seedling explants in callus initiation and plantlet regeneration in triticale**. *Sabrao Journal*, 15: 1, 65-69; 14 ref.

Callus was initiated from root, shoot-base and leaf explants from two-day- old seedlings of line DTS330 and of its induced single-gene dwarf mutant on Linsmaier and Skoog medium containing 2 mg/l 2,4-D. Callus initiation and plantlet regeneration (on the same medium without 2,4-D) were most efficient using shoot bases. The dwarf line had better regenerative ability than DTS330.

234 REDDY, VD; REDDY, GM. 1984. **Induction of useful mutants in triticale**. *Mutation Breeding Newsletter*, No. 24: 7-8; 3 ref.

Hexaploid strains DTS330 and DTS34-3 were treated with ethyl methanesulphonate, diethyl sulphate, hydrazine and gamma rays. Investigations revealed that large-spike, dwarf, dwarf2, long-grain and small-grain mutants were conditioned by single, recessive genes, while an early-heading mutant was controlled by 2 recessive genes. Endogenous GA levels were higher in 2 induced dwarfs than in the control. Seedlings of both dwarfs were unresponsive to external GA3, suggesting that induced dwarfness may be the result of a partial block in GA utilization. There appeared to be an association between grain shrivelling and alpha-amylase and beta-amylase activities in mutants with shrivelled grains. Seedling-shoot bases, as compared with embryos and seedling roots, were best for callus initiation and plant regeneration. An induced monogenic dwarf showed a higher regeneration frequency than the control.

235 REDDY, VD; REDDY, GM. 1983. **Regeneration from glume calli of hexaploid triticale**. *Current Science*, 52: 13, 644-645; 4 ref.

Callus was successfully initiated from triticale glumes on Linsmaier and Skoog (LS) medium with 2 mg 2,4-D/l. The 10-day-old glumes were more efficient for callus initiation than 5- or 15-day-old glumes. Regeneration of plantlets was observed on LS medium supplemented with 0.5 mg kinetin + 0.1 mg NAA/l.

236 REWAL, HS; JHOOTY, JS. 1982. **Correlation between embryo, seedling and field infection of loose smut of wheat**. *Indian Phytopathology*, 35: 4, 571-573; 9 ref., 2 tab.

In the susceptible genotype Sonora 64, a direct correlation was found between embryo and seedlings having > 50% of tissue invaded by mycelium of *Ustilago nuda* and field expression of the disease. Seedlings with < 50% infection became free from loose smut mycelium with the lapse of time.

237 SADHU, D; BHADURI, PN. 1983. **Variable traits of root and shoot of wheat. I. Under embryo cultural condition**. *Zeitschrift fur Acker und Pflanzenbau*, 152: 5, 381-388; 28 ref.

In 28-day-old seedlings grown from embryo cultures of three durum varieties, one variety of *Triticum dicoccum* and 19 *T. aestivum* varieties, marked variation within and between varieties was observed in the number and length of the roots. Drought-resistant varieties, both durum and aestivum, generally had many roots. The late emergence and long period of growth of the seminal roots of *T. aestivum cv. C306* were, it is suggested, associated with its drought resistance. It is also suggested that the narrow range of variation in the number of days taken for the initiation of lateral roots is due to major gene control of this character.

238 SAHA, T; GUPTA, SD; GHOSH, PD; BHATTACHARYYA, SIMA. 1987. **Chromosomal behaviour during culture of *Triticum aestivum L. cv. Kalyansona***. *Experimental Genetics*, 3: 1-2, 33-38; 11 ref.

Cytological studies from squash preparations of callus tissue obtained in vitro from root and leaf segments of the cv. Kalyansona showed large variations in chromosome number in a culture medium supplemented with 2,4,5-T and 2,4-D. The frequency of aneuploid cells was high and 2,4,5-T was more effective than 2,4-D at inducing aneuploidy. Anaphase analysis revealed various chromosomal aberrations including chromatin bridges, asynchronous separation of chromatids, fragmentation, multipolar spindle and laggards, the frequency of which increased with increased concentrations of growth hormones.

239 SATIJA, CK; GILL, KS; DHINDSA, GS; SANDHA, GS. 1991. **Genetic assessment of reciprocal and combining ability effects in octaploid x hexaploid crosses**. *Proceedings of the Second International Triticale Symposium*. Mexico, DF (Mexico). CIMMYT. 1991. p. 110-112.

Twenty-four F1 progenies (2n= 42) obtained by cross-

ing four hexaploids with three octaploids and their reciprocals showed significant differences for grain yield and its components. Octaploid x hexaploid crosses showed superiority over hexaploid x octaploid crosses. Reciprocal cross effects were significant and were ascribable to both female and male parents for grain yield, earliness, harvest index and grain weight as well as interactions. Octaploids and hexaploids differed among themselves with respect to combining ability when used as male or as females. Gene action is primarily nonadditive in both types of crosses. A specific hexaploid should be used as the male and a specific octaploid as the female to obtain more productive secondary triticales.

240 SETHI, GS. 1986. **Introgression of rye traits into bread wheat**. *Eucarpia meeting of the Cereal Section on rye: Proceedings (Part II.* (Svalov, Sweden: 1985: June 11-13). Svalov, Sweden: Svalof AB, p. 605-616; 13 ref.

Ten diverse and agronomically promising Indian triticales were crossed reciprocally with 5 improved amber-grained wheat lines. The F1s were selfed and some were backcrossed with their respective wheat parents. A pedigree breeding procedure was then followed, making single-plant selections for hexaploid wheat-like phenotypes under low to moderate natural epiphytotic conditions of *Puccinia striiformis* and *Erysiphe graminis*. Of 100 F6 derivatives subsequently grown in the field, 29 showed some of 23 mostly morphological traits (described) apparently contributed by rye. These novel traits are thought to have resulted from interaction between the wheat genome and rye chromatin. Some of the derivatives were agronomically promising.

241 SETHI, GS; PLAHA, P. 1988. **The nature of rye (*Secale cereale L.*) chromatin introgression into wheat (*Triticum aestivum L. em. Thell*) via *triticale* (X *Triticosecale Whittmack*)**. *International Wheat Genetics Symposium*. (Cambridge: 7th: 1988: July 13-19)/edited by TE Miller, RMD Koebner. Institute of Plant Sciences Research. p. 433-438; 12 ref.

Twenty-three true-breeding wheat-like triticale X wheat derivatives (RL accessions) with identifiable rye traits were analysed to establish the nature of the rye chromatin introgressed in them using meiotic analysis of the F1 hybrids with wheat and by C-banding analyis of 12 of the derivatives. Meiotic analysis revealed the presence of a single substituted rye chromosome pair in 9 lines and multiple substitutions in 2 lines. In 2 other lines, alien introgression involved whole-arm substitutions, whereas the remaining 10 lines showed no evidence of rye chromatin. Similar alien introgression was observed in the lines analysed using the C-banding technique. The substituting rye chromosomes were 1R, 6R and 7R in RL4, RL22 and RL83, respectively.

242 SETHI, GS; PLAHA, P; GILL, KS. 1988. **Transfer of Karnal bunt (*Neovossia indica (Mitra) Mundkur*) resistance from rye (*Secale cereale L.*) to wheat (*Triticum aestivum L. em. Thell.*)**. *International wheat genetics symposium*. (Cambridge: 7th: 1988: July 13-19)/edited by TE Miller, RMD Koebner. Institute of Plant Sciences Research. p. 439-442; 9 ref.

Ninety-eight advanced generation wheat-like derivatives, resulting from triticale X wheat hybridization, were screened for resistance against 4 N. indica [*Tilletia indica*] pathotypes from Punjab and Himachal Pradesh. Fourteen lines, with phenotypically identifiable rye trait(s), exhibited no incidence of the disease, whereas 7 others were highly resistant. Seven of the 12 lines analysed cytologically had a single substituted rye chromosome pair, one had multiple substitution, and one showed a wheat-rye whole-arm translocation. Remaining 3 lines showed no evidence of rye chromatin. Of the 12, a late-flowering, red-grained and good tillering line, RL7 (no evidence of rye chromatin) was agronomically superior, and 3 others, RL22 (single substitution involving chromosome 6R), RL25 (whole-arm translocation) and RL83 (single substitution involving chromosome 7R), showed resistance to *Ustilago segetum* var. *tritici*.

243 SHARMA, SK; MULTANI, DS; DHALIWAL, HS; GILL, KS. 1988. **Occurrence of free threshing trait in *Triticum durum - T. monococcum amphiploid (AmAmAABB)***. *Current Science*, 57:13, 737-739; 4 ref.

The amphiploids synthesized by chromosome doubling F1 interspecific hybrids were meiotically stable and fully fertile. They showed heterosis for tillers per plant, 100-grain weight, protein content and *Neovossia [Tilletia] indica* resistance but were very hard to thresh (attributed to the *T. monococcum* parent). Amongst 5000 plants of one of the amphiploids raised, one plant with a lax head and chromosome number 2n = 42 showed free threshing. This was thought to have resulted from quadrivalent formation between the 5A chromosomes of *T. monococcum* and *T. durum* (as the gene responsible for free/hard threshing is on 5A between the b1 (awns) and Vrn1 (winter habit) loci) with one gamete receiving both free threshing alleles.

244 SHORAN, J; TANDON, JP; JOSHI, HC. 1983. **Identification of necrosis genes in promising wheat genetic stocks**. *Crop Improv.*, 10: 2, 139-141; 13 ref.

Of 58 new *Triticum aestivum* stocks, classified using testers known to carry the Ne1 or Ne2 genes, 6 were found to carry the Ne1 gene, 43 the Ne2 gene, and 9 neither of these necrosis genes.

245 SHUKLA, RP; PATHAK, KA. 1987. **Spatial distribution of corn-leaf aphid, *Rhopalosiphum maidis (Fitch.)* and its predator *Coccinella septumpunctata Linn*.** *Indian Journal of Agricultural Sciences*, 57: 7, 487-489; 6 ref.

The spatial distribution of the aphid *Rhopalosiphum maidis* and its predator *Coccinella septempunctata* on wheat was studied in the field in Meghalaya, India in the winter of 1984. *R. maidis* had a negative binomial (clumped) and *C. septempunctata* a positive binomial (random) distribution per ear of wheat. It was suggested that this type of model could be utilized effectively for control of the aphid using the coccinellid.

246 SINGH, D. 1990. **Chlorophyll synthetic genes in *Triticum sphaerococcum*.** *Photosynthetica*, 24: 3, 502-505; 8 ref.

Segregation analysis of crosses between the monosomic line 3A of [*T. aestivum*] *cv. Pb. C591* (female) and *T. sphaerococcum* (male) suggested that chlorophyll synthesis in *T. sphaerococcum* is controlled by 2 independent genes, one of which is located on chromosome 3A.

247 SINGH, D. 1991. **Gene transfer from rye to wheat and their location.** *Indian Journal of Genetics and Plant Breeding*, 51: 2, 235-239.

248 SINGH, F; JOSHI, AK; SINGH, BD. 1991. **Identification of Rht genes present in certain indian semidwarf wheat varieties.** *Crop Improvement*, 18: 2, 88-93.

249 SINGH, S; GILL, BS; DHALIWAL, HS; GILL, KS. 1993. **Efforts to identify and tag gene(s) conferring resistance to karnal bunt (*Neovossia indica*) in wheat.** *Progress in genome mapping of wheat and related species*/edited by D Hoisington, A McNab. CIMMYT, Mexico, DF (Mexico) p. 18.

250 SINGH, S; SETHI, GS. 1992. **Expression of 17 rye (*Secale cereale L.*) traits in a range of durum wheat (*Triticum durum Desf*) and bread wheat (*T. aestivum L.*) genetic backgrounds.** *Euphytica*, 60: 1, 37-44; 22 ref.

Expression of 17 rye traits in 24 bread wheat X rye and 8 durum wheat X rye crosses was studied, using a self-compatible, homozygous, dwarf rye. Rye showed epistasis for hairiness on the peduncle in all the crosses. Dark greenness of leaves of rye was expressed in all the durum wheat X rye and in some of the bread wheat X rye crosses. Similarly, absence of auricle pubescence, a rye trait, was expressed in most of the durum wheat X rye crosses but not in the bread wheat X rye crosses, indicating the presence of inhibitors for these traits frequently on the D genome and rarely on the A and/or B genome of wheat. Most of the wide hybrids resembled rye fully or partially for intense waxy bloom on the leaf-sheath and for the absence of basal underdeveloped spikelets. Similarly, most of the amphihaploids resembled rye for anthocyanin in the coleoptile, stem and node. The presence of some inhibitors on A and/or B genome of wheat was indicated in some of the wheat genotypes for the expression of rye traits, viz. intense waxy bloom, anthocyanin in node and absence of basal underdeveloped spikelets. Enhancement in the level of expression of the intensity and length of bristles on the mid-rib of the glume of the hybrids might be due to wheat-rye interaction. Fewer florets/spikelet as in rye showed variable expression in different wheat backgrounds. Some other rye traits such as absence of auricles, terminal spikelet and glume-awn were not expressed in the wheat background. The expression of some of the rye genes might have been influenced by their interaction with *Triticum* cytoplasm and/or the environment.

251 SINGH, SARVJEET; SETHI, G. 1991. **Crossability of some bread wheat landraces and improved cultivars from western Himalayas with rye.** *Euphytica*, 53: 2, 137-141; 25 ref.

The crossability with rye of 62 wheat accessions (14 landraces from Himachal Pradesh and 48 others) was examined. The 3 rye cultivars did not differ in their relative crossability with 4 of the wheat accessions studied. However, the wheat cultivars differed greatly among themselves in their crossability with rye. Most of the wheat cultivars showed poor (<10%) crossability. Two of the 14 landraces from Himachal Pradesh were found to be free from the crossability inhibitors as they showed very high (>50%) crossability, unlike the other 48 cultivars studied.

252 SINGHAL, NC; TOMAR, SMS; PRAKASH, S. 1992. **Phenol reaction on seeds and glumes in wheat species at different levels of ploidy.** *Indian Journal of Genetics and Plant Breeding*, 51: 4, 383-391.

253 SRIDEVI, O; GOUD, JV. 1988. **Trisomic F2 analysis in tetraploid wheat (*Triticum durum*) *cv. HD***

4502 **using the Cappelli trisomic series.** *International wheat genetics symposium*. (Cambridge: 7th: 1988: July 13-19)/edited by TE Miller, RMD Koebner. Institute of Plant Science Research. p. 657-661; 11 ref.

F2 data from crosses of one disomic and 11 trisomic lines (except 1A, 2A and 1B) of Cappelli with HD4502 revealed the location of genes for plant height on chromosomes 4A, 2B and 3B; for tiller number on 3A and 3B; for peduncle length on 4A, 5A, 6A, 7A, 2B and 3B; for spike length on 5A, 2B, 4B and 7B; for number of spikelets per spike on 5A, 4B, 5B, 6B and 7B; for days to heading on 5A, 2B, 4B and 6B; for number of grains per spike on 3A, 5A, 7A, 2B, 4B and 5B; for 100-grain weight on 4A, 6A, 2B and 3B; and for grain yield/plant on 3A, 4B, 5B and 7B.

254 SUSEELAN, KN; RAO, MVP; BHATIA, CR. 1986. **Transfer of a variant allele (Adh-A1b) of alcohol dehydrogenase isozyme gene from durum to aestivum wheat**. *Cereal Research Communications*, 14: 3, 317-318; 5 ref.

The durum wheat cultivar Bijaga Yellow (gai1/rht1, Adh-A1b) was crossed with the semidwarf bread wheat cultivar Rageni (Gai1/Rht1, Adh-A1a). Only 8 grains were produced from 4 pentaploid F1 plants. In the F2, one plant was homozygous for Adh-A1b, and the remainder had Adh-A1a/Adh-A1b. The F3 of the homozygous plant had the morphology of 6x wheat, reasonably good grain set and an alcohol dehydrogenase phenotype with 2 strong bands and a weak third band revealed by electrophoresis. The F4 homozygous for this phenotype segregated for chromosome number; one plant had 20II + 1I. In its progeny were plants with 2n = 6x = 42 with the 3-band phenotype. The differences in banding intensity are attributed to gene dosage effects.

255 SWAMINATHAN, MS. 1989. **Animals and plants: introduction**. *Social consequences of genetic engineering: Proceedings of the sixth Boehringer Ingelheim Symposium*/edited by DJ Weatherall, JH Shelley. Amsterdam: Elsevier Science Publishers, p. 109-126.

The successes and problems associated with the 'Green Revolution' are considered (particularly the production of high yielding semidwarf wheat and rice varieties). While lower and more stable food prices have resulted, there is concern about increased energy and chemical inputs, unemployment and genetic vulnerability of crops. The impact of privatization of research institutes involved in plant breeding is highlighted. It is argued that this might affect level of training for scientists from developing countries, choice of research area and the preservation and free exchange of genetic resources. The Rockefeller Foundation support for the Rice Genetic Engineering Network is highlighted. This paper, together with a paper by J. S. Schell, is discussed on pages 140-151 of these proceedings.

256 TALWAR, SN; JOSHI, MG. 1983. **Efficacy of single crosses versus three-way hybrids in tetraploid *Triticum* species**. *Wheat Information Service*, No. 57: 15-20; 9 ref.

Five tetraploid *Triticum* species and five *T. durum* cultivars were crossed to obtain 20 single cross and 20 three-way cross populations. Variance analysis of data on five yield components from parental and hybrid plants identified many three-way combinations giving increased heterosis over single crosses for the different traits. Some single and three-way crosses showed significant and positive heterosis over both parents for all traits. Six particularly promising three-way crosses are listed. Three-way crosses involving *T. durum* line JNK4w184, unadapted species and adapted *T. durum* cultivars are especially recommended.

257 TANDA, AS. 1992. **Effect of cruciferous tissue cultures and media on the penetration of *Heterodera avenae* in wheat in vitro**. *Nematologia Mediterranea*, 20: 1, 17-19; 11 ref.

The effect of crucifer tissue cultures (*Brassica campestris*, *B. nigra*, *B. juncea* and *Eruca sativa*) and of different media on the penetration of *H. avenae* in wheat using gnotobiotic techniques was determined. MS solidified agar medium (8-12%) was better for propagation and maintenance of excised roots than liquid medium (0.4%). *E. sativa* suppressed penetration of wheat roots by juveniles of *H. avenae* significantly, while the other species suppressed it to a lesser extent.

258 TEWARI, HK; MARWAHA, SS; KENNEDY, JF; SINGH, L. 1988. **Evaluation of acids and cellulase enzyme for the effective hydrolysis of agricultural lignocellulosic residues**. *Journal of Chemical Technology and Biotechnology*, 41: 4, 261-275; 38 ref.

The abilities of mineral acids (hydrochloric and sulphuric acids) and cellulase enzyme from *Trichoderma reesei [T. longibrachiatum]* QM 9414 to hydrolyse maize cob, groundnut shell, sugarcane bagasse and wheat straw were compared. The acids proved better saccharifying agents than the cellulase complex in all cases except maize cob, but gave a poor substrate for alcoholic fermentation since the saccharified mashes contained large amounts of pentoses which are not metabolized by most strs of yeasts.

259 TOMAR, SMS; KOCHUMADHAVAN, M; NAMBISAN, PNN. 1989. **Hybrid weakness in *Triticum dicoccum* Schubl**. *Wheat Information Service*, No. 69: 21-23; 8 ref.

Hybrid necrosis and hybrid chlorosis are each governed by 2 dominant complementary genes, Ne1 and Ne2, and Ch1 and Ch2, respectively. Two *T. aestivum* testers, C306 (Ne1ne2 ch1Ch2) and Sonalika (ne1Ne2 ch1Ch2), were crossed with 9 varieties of *T. dicoccum*. Results revealed that 5 of the *T. dicoccum* varieties carried Ne1 and 7 carried Ch1; HW43, HW1018, HW1046 and Khapli-53 Yellow carried both.

260 VISHWAKARMA, SR; MANI, SC. 1985. **Crossability between triticale X wheat and reversion patterns in early segregating generations**. *Current Science*, 54: 1, 42-43; 4 ref.

Four hexaploid triticale strains were crossed as females with the *T. aestivum* varieties HD2009 and UP262, during rabi 1980-81. Crossability (No. of grains set as a percentage of pollinated florets) averaged 8.16%, ranging from 1.6% in PR673 X UP262 to 18.2% in UPT75233 X H2009. Plants in the early segregating generations (F2, B1 and B2) were classified as triticale, wheat or intermediate types, and useful transgressive segregates were observed in all generations.

261 WANJARI, KB; CHOPRA, VL; JOSHI, MG. 1992. **Studies on triticale wheat crossability**. *Journal of Genetics and Breeding*, 46: 3, 279-282.

Crossability was studied among seven secondary triticales and six wheat genotypes. Wheat x triticale crosses showed hih percentages of seed setting but the seeds were illfilled and poor in germination, which was in contrast to their reciprocals. The reciprocal differences were attributed to selective elimination of abnormal gametes of triticale on male side only. Genotypic differences for crossability were seen in both wheats and triticales. The Kr gene system of Krolow was found to operate in the presence of a particular rye chromosome rather than against the whole rye genome.

Hybridization

262 ANSARI, BA; RAJPER, MM; MALIK, AJ; ANSARI, KA. 1990. **Heterosis studies in some intraspecific hybrids of wheat (*Triticum aestivum L.*)**. *Pakistan Journal of Agriculture, Agricultural Engineering Veterinary Sciences*, 6: 1-2, 37-40.

263 BAJAJ, YPS. 1983. **Survival of somatic hybrid protoplasts of wheat X pea and rice X pea subjected to -196°C**. *Ind. J. of Exp. Biol.*, 21: 3, 120-122; 6 ref.

Protoplast hybrids of *Pisum sativum cv. PG5* with *Triticum aestivum cv. Kalyan Sona* and *Oryza sativa cv. B370* were frozen in liquid N and then thawed at 35°C. Survival (signs of growth) in pea (X) wheat was slightly higher (12.2-17.9%) than in pea (X) rice (10.8-13.9%). Heterokaryons showed two nuclei of different sizes; occasionally fusion of nuclei was apparent. Only one retrieved hybrid cell underwent repeated division.

264 FAROOQ, S; IQBAL, N; ASGHAR, M; SHAH, TM. 1992. **Intergeneric hybridization for wheat improvement. VI: Production of salt tolerant germplasm through crossing wheat (*Triticum aestivum L.*) with *Aegilops cylindrica* and its significance in pratical agriculture**. *Journal of Genetics and Breeding*, 46: 2, 125-132.

Modified wheat plants with 42 chromosomes were produced through crossing hexaploid wheat with salt tolerant accessions of *A. cylindrica*. F1 hybrids with 35 chromosomes were backcrossed with recurrent wheat parent. Only 42 chromosomes BC1 plants were selfed twice to produce BC1 self fertile derivatives. These derivatives were then tested for salt tolerance. Screening was conducted by germinating the seeds on filter papers moistened with saline solutions of EC 3 (control), 15, 20 and 25 dS/m and by growing two-weeks old seedlings in gravel tanks maintained at the above salinity levels by a step-wise increase in electrical conductivity. Plants were grown there till maturity. Seed germination was observed at all salinity levels, but a delay and significant reduction in germination in some plants was observed at higher salinity levels. All the plants survived at EC 15 dS/m, but only six produced grains while three survived at EC 20 dS/m and only one produced grains. None of the plants survived till maturity at EC 25 dS/m. The observed level of salt tolerance and yield potential of the presently tested germplasm was higher compared to the germplasm tested earlier. The results have been discussed with reference to their significance in practical agriculture.

265 FAROOQ, S; IQBAL, N; SHAH, TM. 1990. **Intergeneric hybridization for wheat improvement. III. Genetic variation in *Triticum* species affecting homoeologous chromosome pairing**. *Cereal Research Communications*, 18: 3, 233-237; 17 ref.

Meiotic analysis was performed on metaphase I chromosomes in hybrids between 5 wheat varieties and *Aegilops variabilis* accession E, which increases homoeologous chromosome pairing, and accessions A and B which do not have this ability. Significant differences were found

in the mean chiasma frequencies in hybrids involving different wheat varieties and *A. variabilis* E (chiasma frequency range 5.1-6.9/cell). No combination yielded a chiasma frequency equal to or greater than that observed in the hybrid LU26 X *A. variabilis* E (13.2). The *A. variabilis* accessions A and B also showed higher chiasma frequency after hybridization with LU26. Significant variation in chiasma frequency occurred with respect to both the wheat varieties and the *A. variabilis* accessions.

266 FAROOQ, S; IQBAL, N; ASGHAR, M; SHAH, TM. 1992. **Intergeneric hybridization for wheat improvement. IV. Expression of salt tolerance gene(s) of *Aegilops* cylindrica in hybrids with hexaploid wheat**. *Cereal Research Communications*, 20: 1-2, 111-118; 14 ref.

Expression of salt tolerance gene(s) in *A. cylindrica* was studied in hybrids of hexaploid wheats with different salt tolerant accessions of *A. cylindrica*. Screening was conducted at conductivity levels of EC 3, 15, 20 and 25 dS/m. All F1 hybrids survived until flowering at EC 15, some at EC 20 and none at EC 25 dS/m. Those surviving at EC 15 dS/m showed varied growth responses. Except for one combination (Pak-81 X *A. cylindrica* accession 502242), which produced shrivelled seeds, most of the F1 hybrids could not be backcrossed under saline conditions. BC1 seeds produced under non-saline conditions generally possessed 40, 41, or 42 chromosomes. Meiotic analyses of 41- and 43-chromosome plants indicated average chromosome pairing levels of 1-3 univalents and 19-21 bivalents. BC1 plants with Pak-81 and Lu-26 as female parents and with 42- and 44-chromosome plant progenies showed varied salt tolerance responses.

267 TOMAR, SMS; VARI, AK. 1992. **Analysis of meiotic pairing in hybrids of common wheat with three alien species**. *Indian Journal of Genetics and Plant Breeding*, 52: 1, 11-16.

268 VISHWAKARMA, SR; MANI, SC. 1983. **Expression of necrosis in triticale X wheat hybrids**. *Crop Improvement*, 10: 2, 132-135; 11 ref.

The 16 hybrids obtained by crossing 2 indigenous *Triticum aestivum* cultivars with 8 hexaploid strains of triticale showed necrosis ranging from weak (less than 40% of plants killed before maturity) to severe (all plants killed before maturity). Most triticale strains seemed to carry the Ne2 gene from *T. aestivum*. There were 3 alleles (weak, moderate and strong) at the loci Ne1 and Ne2.

Anther culture

269 DARVEY, NL; RIMES, A; ALI, JA FAZAL; BARBERA, F; ANCORA, G. 1991. **A modified anther culture methodology for increasing embryoid production in wheat and triticale.**. *Proceedings of the Second International Triticale* Symposium. (Mexico, D.F.: 2nd: 1991). Brazilian Agricultural Research Enterprise, Passo Fundo (Brazil). National Wheat Research Center. p. 314-319.

The induction of androgenetic haploids was attempted for wheat and triticale by using a semisolid medium with a thin layer of liquid on top. The liquid media was allowed to saturate a sterile filter pad on which the anthers were plated. This technique appeared to be more effective than a semisolid medium for induction and for the subsequent differentiation of embryoids into plantlets. A positive effect of an amino acid supplement was also observed. Other media combinations have also been examined, including the use of agarose media, various hormones and different reducing sugars. The use of a polypropylene membrane raft for supporting anthers in a liquid medium has also been successfully utilized.

270 DUBE, SD. 1984. **Genotypic differences for callus formation in immature anthers of wheat**. *Crop Improvement*, 11: 1, 64-65; 5 ref.

Anthers at the early tetrad stage were taken from 14 winter and 5 spring cultivars and cultured on 3 basic media. Callus formation occurred only on Murashige & Skoog medium supplemented with 2,4-D. Callus was formed by up to 1.6% of anthers from 7 of the winter cultivars, but from none of the spring cultivars.

271 KARIM, MA; MEHTA, SL; SINGH, MP. 1984. **Studies on esterase isoenzyme pattern in anthers and seeds of male sterile wheats**. *Zeitschrift fur Pflanzenzuchtung*, 93: 4, 309-319; 14 ref.

Esterase isoenzyme patterns obtained by polyacrylamide gel electrophoresis and isoelectric focusing from anthers and grains of the cytoplasmic donor *Aegilops comosa*, 8 hexaploid wheat cultivars as nucleus donors and the cytoplasmically male sterile lines derived from them, differed quantitatively and qualitatively. Zymogram patterns showed fewer bands in anthers of the male sterile lines than in their wheat parents. Many isoenzymes in the grains of the male sterile lines could be traced to one of the parents, but a few were new. The presence of nucleocytoplasmic interaction is suggested.

272 KHAN, NU; HUSSAIN, M; SHAHID, TH. 1989. **Impact of anther culture on wheat breeding**. *Journal of Agricultural Research Lahore*, 27: 3, 175-183; 23 ref.

The role of anther culture in haploid production is discussed. The best conditions for anther culture are examined, including especially potato II and N6 media (at culture temperatures of 26-30 °C). For callus initiation, the media are supplemented, respectively, with 2,4-D and 2,4-D + kinetin, for callus differentiation with kinetin + IAA and kinetin + NAA and for rooting with IAA + kinetin and no growth regulators.

Avena sativa

273 CHOUBEY, RN; PREMACHANDRAN, MN; GUPTA, SK. 1985. **Effect of *Avena sativa* genotype 'JHO 801' on chromosomal association in interspecific hybrid with *A. magna***. *Indian Journal of Genetics and Plant Breeding*, 45: 1, 138-140; 7 ref.

The experimental hexaploid JHO801 (female) was crossed with the tetraploid species *A. magna*. The mean frequencies of univalents, bivalents, trivalents and quadrivalents in the self-sterile pentaploid hybrid were 4.6, 11.3, 0.7 and 1.4, respectively. These values are more favourable than those previously reported for similar interspecific hybrids involving *A. magna*. It is suggested that a high frequency of bivalents and low frequency of univalents can be achieved by the use of *A. sativa* lines such as JHO801, thus increasing the likelihood of useful gene transfer from *A. magna* to *A. sativa*.

274 FREY, KJ; COX, TS; RODGERS, DM; COX, PJ BRAMEL. 1983. **Introgression of wild germplasm in oats, barley, sorghum, and pearl millet**. *Agronomy Abstracts*, p. 64.

Populations of these cereals containing 1-50% introgressed germplasm from respective wild relatives were evaluated for yield components. Some oat and barley introgression lines, tested in Iowa, USA, gave up to 40% more grain than their recurrent cultivated parents. Highest transgressive segregation frequency (up to 18%) occurred in the BC4. High-yielding sorghum introgression lines, tested in India, were also obtained, but at low frequency. Yield increases in oats, and possibly barley, were attributed mainly to increased vegetative growth rate index. It is suggested that genes from wild *Pennisetum* could double the growth rate of *P. americanum* varieties, as tested in India, and possibly increase grain yield.

275 KISHOR, C; PARODA, RS; JATASARA, DS. 1992. **Epistatic gene effects from the triple test cross analysis in F2 population of oats for forage yield and quality**. *Indian Journal of Genetics and Plant Breeding*, 52: 1, 50-54.

276 MALIK, JS; JATASRA, DS; SOLANKI, KR. 1989. **Separation of epistatic effects from additive and dominant gene effects for tillering in oats (*Avena sativa L.*)**. *Indian Journal of Agricultural Research*, 23: 4, 187-190; 12 ref.

Information on heterosis and genetic variance is derived from data on tillering in parents, F1s, F2s and backcrosses from 3 oat crosses grown in Hissar. Only cross HFO55 X HFO104 exhibited heterosis over the better parent; epistatic interactions were also detected in this cross. Low tiller number was determined mostly by dominant genes and additive effects were significant in all crosses.

277 MANGA, VK; SIDHU, BS. 1984. **Diallel analysis of some quantitative traits in forage oat**. *Indian Journal of Agricultural Sciences*, 54: 1, 36-40; 10 ref.

Four forage yield related characters were studied in a diallel cross, without reciprocals, involving 9 varieties of *Avena sativa* and 1 of *A. byzantina*. Graphical and component of variance analysis revealed both additive and nonadditive gene action, partial dominance for days to flowering and number of leaves/well-developed tiller, overdominance for leaf size and complete dominance for leaf : stem ratio. General combining ability (GCA) effects were more important than specific combining ability effects and the mean performance of the parents gave a good indicatioon of their GCA for all traits except leaf : stem ratio. Heritability was high for all characters.

278 MANGA, VK; SIDHU, BS. 1984. **Genetic analysis of fodder yield in oat**. *Indian Journal of Agricultural Sciences*, 54: 8, 621-624; 6 ref.

Results from a 10-parent diallel cross, without reciprocals, involving 9 *Avena sativa* varieties and one of *A. sterilis* indicated that the *A. sativa cv. Appler* was the best general combiner for fodder yield and that the mean performance of the parents was not a good indication of their general combining ability. Three cross combinations showed high heterosis. Both additive and nonadditive gene effects with complete dominance influenced fodder yield.

Maize

279 DESJARDINS, AE; PLATTNER, RD; SHACKELFORD, DD; LESLIE, JF; NELSON, PE. 1992. **Heritability of fumonisin B1 production in *Gibberella fujikuroi* mating population A**. *Applied and Environmental Microbiology*, 58: 9, 2799-2805.

Fumonisins are mycotoxins by strains belonging to several different mating populations of *Gibberella fujikuroi* (anamorphs, Fusarium section Liseola), a major pathogen of maize and sorghum worldwide. We studied the heritability of fumonisin production in mating population A by crossing fumonisin-producing strains collected from maize and sorghum in the United States with fumonisin- nonproducing strains collected from maize in Nepal. Random ascospore and tetrad progeny from three of these crosses were analyzed by gas chromatography-mass spectrometry and high-performance liquid chromatography. In all three crosses, the ability to for their ability to produce fumonisins on autoclaved cracked maize. In all three crosses, the ability to produce fumonisins, predominately fumonisin B1, segregated as a single gene or group of closely linked genes. Intercrosses between appropriate progeny and parents were poorly fertile, so we could not determine if the apparent single genes that were segregating in each of these crosses were allelic with one another. Mating type and spore-killer traits were scored in some crosses, and each segregated, as expected, as a single gene that was unlinked to the ability to produce fumonisins. We conclude that *G. fujikuroi* mating population A provides a powerful genetic system for the study of this important fungal toxin.

280 KHATUN, R; ARA, M; HOSSAIN, MT. 1995. **In vitro plant regeneration of *Zea mays L.*** *Annual Plant Tissue Culture Conference*. (Dhaka University, Dept. of Botany: 1995: March 19).

281 SARMA, JSP; SHARMA, AK. 1984. **Amount of DNA in different strains of maize and its importance in selection**. *Proc. of Indian National Science Academy, Part B: Biological Sciences*, 50: 1, 107-112; 12 ref.

There was no significant difference in DNA content as estimated cytophotometrically among the 18 cultivars examined. These differed karyotypically, in the presence or absence of B chromosomes and of heterochromatin "knobs"

282 SUPRASANNA, P; RAO, KV; REDDY, GM. 1986. **Isolation of protoplasts from seedlings**. *Maize Genetics Cooperation Newsletter*, No. 60: 66.

A technique for the isolation of maize protoplasts for use in genetic manipulation and plant regeneration experiments is briefly described. The best yields of protoplasts (1 X 106/g tissue) were obtained from stem sections, which also required a shorter period of enzyme treatment than did leaf explants.

Hybridization

283 ABBAS, N. 1991. **Phenotypic and genotypic correlation for grain yield and foliar characters in maize (*Zea mays L.*)**. UAF, Faisalabad (Pakistan) 96 p.

284 AHMAD, R. 1991. **Study of heterosis and combining ability in maize (*Zea mays L.*) single crosses.** UAF, Faisalabad (Pakistan) 86 p.

285 AHMED, S; MIAN, MA; GILL, AR. 1992. **Correlation studies between yield, yield components and oil content in maize single crosses**. *Pakistan Journal of Agricultural Research*, 13: 2, 132-135.

286 DHILLON, BS. 1991. **Alternate recurrent selection of S1 and half-sib families for intrapopulation improvement**. *Maydica*, 36: 1, 45-48.

287 HUSSAIN, M. 1991. **Heterosis and combining ability in (*Zea mays L.*) single crosses.** UAF, Faisalabad (Pakistan) 90 p.

288 IRSHAD, M. 1991. **Estimation of heterosis and combining ability in maize (*Zea mays L.*) inbred lines by top crosses**. UAF, Faisalabad (Pakistan) 80 p.

289 O'TOOLE, JC. 1989. **Breeding for drought resistance in cereals: emerging new technologies.** *Drought resistance in cereals: Proceedings of a Symposium*. (Cairo, Egypt: 1988: 28-30 November)/edited by FWG Baker. CAB International, Wallingford, UK. p. 81-94, 38 ref.

The future role of genetic engineering (gene identification, location, cloning and introduction into a target genome) utilizing recombinant DNA technology for improvement of drought resistance will require the generation of an extensive information base for each component trait. One technique, restriction fragment length polymorphism (RFLP), however, may be applied immediately. Its value and role in pre- and post-gene transfer physiological and genetical studies is discussed with examples of traits related to drought resistance in

maize and rice. Molecular markers and protoplast culture are also covered briefly.

290 ROSALES, TP; MOLINA, M DEL-C. 1984. **Cytogenetic study of the hybrid *Zea mays* X *Zea diploperennis***. *Nucleus, India*, 27: 3, 242-245; 9 ref.

Vigorous, fertile hybrids (2n = 20) from crossing the 2 species had regular meiosis; 69.06% of the cells examined had 10II, 24.3% had 9II + 2I, 6.08% had 9II + 4I and the remainder 7II + 6I. The average figure of 15 chiasmata/cell was similar to that for *Z. diploperennis* (14). At anaphase I, in 58.5% of the cells examined, 10 chromosomes migrated to each pole; in the remainder, various numbers migrated and there were lagging chromosomes and chromatid bridges. An inversion in the long arm of chromosome 5 was observed at pachytene. The hybrids showed a considerable increase in the size of chromosome knobs over the size found in the parental species. From these studies, it is concluded that *Z. mays* and *Z. diploperennis* have some chromosome affinities.

291 SAMAR, MS. 1992. **Study of morphogenetic characters of advanced generations of maize x teosinte hybrids.** UAF, Faisalabad (Pakistan) 92 p.

292 SINGH, HK. 1984. **Plantlets from leo-maize anthers in vivo**. *Maize Genetics Cooperation Newsletter*, No. 58: 152-153.

In some progenies from maize X teosinte [*Euchlaena mexicana*] crosses, plantlets were observed to emerge from tassel spikelets in place of normal anthers. The plantlets grew, produced roots and matured on the mother plant, attaining a height of 40-60 cm and having normal male and female meiosis and fertility. When these plantlets were removed from the tassel and transplanted to the field they grew into almost normal plants and produced fertile progenies.

Cell culture

293 DEY, SK; BANSAL, UK; SAXENA, VK; KHEHRA, AS. 1993. **Use of natural additives - A new dimension in improving plant regeneration from callus cultures of maize (*Zea mays L.*)**. *Annals of Biology*, 9: 1, 38-41.

294 DHINGRA, HR; VARGHESE, TM. 1985. **Effect of growth regulators on the in vitro germination and tube growth of maize (*Zea mays L.*) pollen from plants raised under sodium chloride salinity**. *New Phytologist*, 100: 4, 563-569; 35 ref.

The effect of various growth regulators on in vitro germination and tube growth of pollen grains collected from maize cv. D-741 plants raised under conditions of 0, 80, 120 and 160 meq/l salinity were investigated. IAA had no effect on pollen germination, irrespective of the source of pollen, but low concn. enhanced tube growth in pollen from salinized plants. 1 mg GA3/l antagonized the depressive effect of 120 meq/l salinity on pollen germination. GA3 stimulated tube growth of pollen from both saline and non-saline plants, but pollen from salinized plants required a higher concn. Benzylaminopurine ameliorated the inhibitory effects of NaCl salinity both on germination and tube growth of pollen. ABA inhibited germination to a greater extent in pollen from non-saline than saline plants but stimulated tube growth in all cases. It was concluded that pollen from salinized plants responds more to growth regulators than that from non-salinized plants.

295 JYOTI; DHINGRA, HR; VARGHESE, TM. 1990. **Explant cultures of maize (*Zea mays L.*) raised under water-deficit and waterlogged conditions**. *New Phytologist*, 116: 2, 325-330.

296 KINUGAWA, K; TANIMOTO, Y. 1987. **Variability in callus forming ability of corn races native to Latin America and Nepal**. *Japanese Journal of Breeding*, 37: 3, 341-344; 5 ref.

Thirty-five Latin American, 7 Nepalese and 2 Japanese native maize races were compared for callus initiation and growth from mature embryo scutellum on modified Murashige & Skoog medium with 2,4-D. Large differences between races were noted within the Latin American and Nepalese groups, and some Latin American genotypes segregated for genotypes differing in callus initiation ability. None of the races was capable of plant regeneration from callus on medium without 2,4-D.

297 MOHANTY, BD; PAUL, NK; GHOSH, PD. 1986. **Chromosomal behaviour in callus culture of *Zea mays L.***. *Cytologia*, 51: 1, 37-41; 11 ref.

Calluses obtained from root explants of an unspecified composite variety showed a range of mitotic abnormalities after 3-60 days in culture, including inhibition of cell plate formation, chromosome breakage, stickiness and clumping of chromosomes, lagging chromosomes and the formation of micronuclei. A wide range of aneuploid and polyploid chromosome numbers was observed. Chromosome structural changes, including a putative deletion, were identified by chromosome banding.

298 PAUL, NK; GHOSH, PD. 1984. **Cytological behaviour during callus culture of *Zea mays L.*** *Chromosome Information Service*, No. 37: 6-8; 4 ref.

Of 66 dividing cells observed at the time of callus induction, 46.9% showed aneuploidy and 34.8% had the diploid number of chromosomes. After 58 days in culture, 4.47% of cells were polyploid, and after 84 days 58.8% were aneuploid, 41.1% diploid and 7.33% polyploid. Binucleate cells, micronuclei, chromosome clumping and unequal groupings were also observed.

299 RAO, KV; SUPRASANNA, P; REDDY, GM. 1990. **Biochemical changes in embryogenic and non-embryogenic calli of *Zea mays L.*** *Plant Science*, 66: 1, 127-130.

300 RAO, KV; SUPRASANNA, P; REDDY, GM. 1984. **Cross feeding and pigment synthesis in root cultures**. *Maize Genetics Cooperation Newsletter*, No. 58: 100.

Callus and regenerated-root extracts of maize with different anthocyanin genotypes in 1% methanolic HCl gave absorption maxima of 530 nm in the Pr genotype, 520 nm in pr and 210 and 260 mn in c2, suggesting that the accumulated pigments present may be cyanidin, pelargonidin and cinnamic acid, respectively. Immature grains of C-I were germinated in vitro on a medium supplemented with caffeic acid. Purple pigment was observed in the regenerated roots, suggesting that C-I may use caffeic acid in the synthesis of anthocyanin.

301 RAO, KV; SUPRASANNA, P; REDDY, GM. 1989. **Genotypic differences and effect of amino acids on somatic embryogenesis in immature embryo calli**. *Maize Genetics Cooperation Newsletter*, No. 63: 80.

Of the immature embryos of maize inbreds CM117, CM119, CM120, CM400, CM111, hybrid DHM1 and sweetcorn, DHM1 had the highest frequency of somatic embryogenesis (52%) in vitro, compared with 10-38% for the other genotypes, on MS medium supplemented with 2 mg 2,4-D + 3% sucrose. Against a background of MS medium + 2,4-D, 10-15 mM L-proline enhanced the frequency of embryogenesis by about 15%. *Tryptophan* was inhibitory while asparagine and glutamic acid had no effect on embryogenesis. Plants were regenerated from DHM1 and sweetcorn cultures.

302 RAO, KV; SUPRASANNA, P; REDDY, GM. 1985. **Induction of somatic embryos from root callus**. *Maize Genetics Cooperation Newsletter*, No. 59: 51.

Cultures were initiated from seedling roots of different maize genotypes on LS [Linsmaier & Skoog] medium containing 2 mg 2,4-D/litre. After one month the cultures were transferred to medium containing 1 mg 2,4-D/litre and 0.5 mg NAA/litre on which they were maintained through 5-6 subcultures. Compared with these media, hormone-free media gave rise to more somatic embryoids. On transfer to media containing different amounts of hormones, some embryoids produced roots but not shoots.

303 RAO, KV; SUPRASANNA, P; REDDY, GM. 1989. **SEM and TEM characterization of embryogenic calli**. *Maize Genetics Cooperation Newsletter*, No. 63: 80.

Scanning electron microscopy (SEM) and transmission electron microscopy (TEM) revealed clear differences between embryogenic maize calluses and non-embryogenic calluses that had originally been separated from primary callus initiated from embryos. In addition to the characteristic features of scutellum and coleoptile, SEM showed the presence of numerous globular structures. In the TEM studies, embryogenic cells had thin walls with uniformly distributed cytoplasmic material, whereas non-embryogenic calluses showed thick cell walls with little cytoplasm in their vicinity.

304 RAO, KV; SUPRASANNA, P; REDDY, GM. 1986. **Somatic embryogenesis in glume callus cultures**. *Maize Genetics Cooperation Newsletter*, No. 60: 64-65.

Callus induced from glumes of maize and sweetcorn was cultured on MS [Murashige & Skoog] medium. Optimal conditions for somatic embryogenesis required a sucrose concentration of 2-3%, supplementation with 2 mg 2,4-D/litre and a higher nitrate concentration than normal in MS medium. Preliminary studies on various enzymes revealed differences in isoenzyme activity and/or pattern between embryogenic and nonembryogenic callus.

305 RAO, KV; SUPRASANNA, P; REDDY, GM. 1989. **Studies on enzyme and isozyme patterns in embryogenic glume calli of maize**. *Proceedings of the Indian National Science Academy. Part B, Biological Sciences*, 55: 4, 277-280; 21 ref.

Glumes inoculated on MS medium supplemented with 2 mg 2,4-D/litre formed callus within 2 weeks. Embryogenic calluses showed high activities of peroxidase and polyphenol [catechol] oxidase. Two slow migrating bands of isoperoxidases and specific esterases were present in embryogenic calluses and absent in non-embryogenic cultures indicating a possible association of these enzymes with somatic embryogenesis in vitro.

306 SHARMA, BK; GUPTA, RK; CHAND, L. 1990. **Influence of drought stress on photosynthesis and photorespiration in callus tissue of maize**. *Photosynthetica*, 24: 1, 143-146; 12 ref.

Maize cv. Pant D-831 callus cultures were grown in 100, 96, 80 and 65% RH in the presence of 14CO2. Both photosynthesis and chlorophyll content decreased with decrease in RH. The amount of photorespiratory 14CO2 evolved due to decarboxylation of 14C-glycine, increased as RH decreased. It is suggested that drought stress may induce a gradual shift of C flow from the C4 carbon fixation pathway to an alternate (glycollate) pathway in maize callus.

307 SUPRASANNA, P; RAO, KV; REDDY, GM. 1990. **Anthocyanin synthesis during embryogenesis in vitro**. *Maize Gen. Coop. Newsletter.*, No. 64: p. 66-67.

Immature embryos of pigmented maize cv. Deccan Hybrid Macca were cultured on MS medium with 2,4-D added at 2 mg/litre. Subcultured calluses exhibited embryogenic and non-embryogenic sectors. Upon transfer to hormone-free regeneration media, embryogenic clumps exhibited anthocyanin synthesis followed by embryoid differentiation. After 6-8 days embryoids became green. It is suggested that this anthocyanin synthesis may be used in studies of in vitro differentiation.

308 SUPRASANNA, P; RAO, KV; REDDY, GM. 1985. **Effect of 2,4-D analogues on callus cultures**. *Maize Genetics Cooperation Newsletter*, No. 59: 50-51.

In tests in which Murashige & Skoog and Linsmaier & Skoog basal media were supplemented with 0.5-4 mg 2,4-D, 2,4,5-T or 2,4,5-P (= 2-(2,4,5- trichlorophenoxy)propionic acid) per litre, 0.5 mg 2,4,5-T or 2,4,5-P was superior to 2,4-D for callus initiation from maize root cultures while 2,4-D was superior for use with glume explants. Multiple root formation occurred with low amounts of all 3 auxins.

309 SUPRASANNA, P; RAO, KV; REDDY, GM. 1989. **Effect of growth regulators on anthocyanin synthesis in maize endosperms cultured in vitro**. *Biologia Plantarum*, 31: 3, 177-181; 12 ref.

Immature maize grains at 10 d after pollination were collected from field-grown plants of the anthocyanin-producing maize genotype ACRPr, surface-sterilized and the endosperms were scooped out and cultured on Murashige and Skoog medium supplemented with 2,4-D, IAA, NAA, BA or kinetin at different concn and in various combinations. Low concn of IAA (0.5 mg/litre) and kinetin (1.0 mg) increased anthocyanin production by 3- and 5-fold, resp., and 1.0 mg of each increased anthocyanin production 5-fold compared with a control medium with no added growth regulators.

310 SUPRASANNA, P; RAO, KV; REDDY, GM. 1989. **Genetically controlled anthocyanin synthesis in callus cultures of *Zea mays L.***. *Proceedings of the Indian Academy of Sciences, Plant Sciences*, 99: 3, 293-295; 9 ref.

Callus cultures were established on Linsmaier & Skoog medium (supplemented with 2 mg 2,4-D/litre) from seedling root explants of 2 lines of maize genotype W22; one line had gene Pr for purple (cyanidin) pigmentation of the aleurone while the other had pr for red (pelargonidin) pigmentation. Coloured sectors were observed on calluses and regenerated roots. Although there were not enough pigments for complete analysis, Rf values and absorption maxima for the anthocyanins from the cultures were obtained. These proved to be similar to those obtained for the anthocyanins from the aleurones of the original donors.

311 SUPRASANNA, P; RAO, KV; REDDY, GM. 1987. **Initiation and maintenance of suspension cultures**. *Maize Genetics Cooperation Newsletter*, No. 61: 58-59.

Friable calluses derived from seedling roots of the maize genetic stocks A1888, Pr and rr were transferred into liquid MS [Murashige & Skoog] basal media containing 2,4-D or its analogues 2,4,5-T or 2,3,5-trichloroproprionic acid (2,4,5-P). After a week the suspension mostly consisted of cell aggregates (2 mm) and some single cells (5-10%). An intermediate 2,4-D concentration (2 mg/litre) gave the highest proportion of single cells and small aggregates. A finer cell suspension was obtained with 2,4-D than with 2,4,5-T or 2,4,5-P. A188 gave a better cell suspension than the other types.

312 SUPRASANNA, P; RAO, KV; REDDY, GM. 1986. **Plantlet regeneration from glume calli of maize (*Zea mays L.*)**. *Theoretical and Applied Genetics*, 72: 1, 120-122; 15 ref.

Callus cultures were established from anther-free glumes of 4 cultivars on Murashige & Skoog medium supplemented with 2,4-D. Glumes excised at the uninucleate stage of pollen development showed a higher rate of callus initiation than those at the binucleate stage, and callus initiation was highest in the cultivar designated Sweet Corn. Organogenesis and plant regeneration occurred on subculturing; regenerative ability was highest for cv. Sweet Corn.

313 SUPRASANNA, P; RAO, KV; REDDY, GM. 1984. **Studies on growth pattern in root callus cultures**. *Maize Genetics Cooperation Newsletter*, No. 58: 99.

On Linsmaier & Skoog medium with 2,4-D, growth of callus was initiated from 1-week-old maize seedling roots of haploids (selected from crosses of C X C-I stocks) and diploids. Growth was slower in haploids (0.5 ± 0.05 g after 1 month) than in diploids (1.01 ± 0.10 g after 1 month). Callus from haploids produced more roots than that from diploids.

Insect pests control

314 BEHURA, BK; DASH, AP. 1983. **Studies on the embryonic development in the common maize aphid *Rhopalosiphum maidis* (Fitch)**. *Pranikee*, 4, 132-146; 10 ref.

Seven stages are recognized in the embryonic development of *Rhopalosiphum maidis* collected from maize in India. The durations of the 2nd-7th stages at 25 +- 3.5°C and 68% RH were 22-28, 4-7, 5, 8, 17-21 and about 9 h, respectively. The first (egg) and second stage embryos appeared in the 3rd nymphal instar of the parent.

315 CHOUDHARY, AK. 1992. **Influence of microbial co-inhabitants on aflatoxin synthesis of *Aspergillus flavus* on maize kernels**. *Letters in Applied Microbiology*, 14: 4, 143-147; 9 ref.

The co-inhabiting mycoflora associated with *A. flavus* on individual maize grains was evaluated for its influence on aflatoxin synthesis. All 13 types of associations of different fungal species with *A. flavus* inhibited aflatoxin B1 and G1 production at different levels (34.3-100%). Inhibition of aflatoxin B1 was consistently less than that of G1. Inhibition of radial growth of *A. flavus* by *Fusarium moniliforme* [*Gibberella fujikuroi*] (59.8%), *Trichoderma viride* (72.5%) and Rhizopus nigricans [*R. stolonifer*] (42%) could be directly correlated to the percentage inhibition of aflatoxin production. High levels of inhibition of aflatoxin elaboration were noted in competition of *A. flavus* with other toxigenic moulds.

Other aspects of Maize

316 DEVI, MT; RAGHAVENDRA, AS. 1992. **Light activation of phosphoenolpyruvate carboxylase in maize mesophyll protoplasts**. *Journal of Plant Physiology*, 139: 4, 431-435; 28 ref.

The effect of light (darkness or 1000 μmol/m2/s) on phosphoenolpyruvate (PEP) carboxylase activity in maize cv. Ganga 5 mesophyll protoplasts was examined. When protoplasts were illuminated in a low-buffered (2 mM) medium, PEP carboxylase activity increased 20-35% over that in darkness. There was no light activation, however, if the protoplasts were kept in a high-buffered (20 mM) medium. Maximum activation occurred after 10-15 min of illumination and the activation was lost within 8 min after transfer to darkness. The light activation of PEP carboxylase was completely supressed by phlorizin or CCCP, but not by DCMU. The characteristics of the light activated form of PEP carboxylase in protoplasts (in situ) differed slightly from those observed with leaves (in vivo). It is suggested that light-induced alkalization of the cytosol and ATP formation are involved in the activation of PEP carboxylase, possibly through phosphorylation of the enzyme.

317 PAUL, NK; GHOSH, P. 1984. **Production of maize pollen embryoids and the influence of some factors on their frequency of induction**. *Maize Genetics Cooperation Newsletter*, No. 58: 105-106.

Conditions for induction of callus or embryoids from anthers of 2 cultivars were optimum when flower buds were cold pretreated at 7°C for 4 days and anthers were cultured on N6 basal medium supplemented with 12% sucrose, 2 or 4 mg 2,4-D/litre, 1 mg kinetin/litre and ±500 mg casein hydrolysate/litre. Anther-derived callus was on average 52% haploid, 26% diploid and 22% mixoploid.

Barley

318 AMIN, MN; ALAM, S; ISLAM, A. 1982. **Cytomorphological changes in barley induced by Carbicron and vapona**. (*Abst.) 6th Annual Bangladesh Sci. Conf.* Joydevpur, , Bangladesh).

319 DATTA, SK. 1987. **Plant regeneration by pollen embryogenesis from cultured whole spikes of barley (*Hordeum vulgare*)**. *Theoretical and Applied Genetics*, 74: 1, 121-124; 27 ref.

Cultures were established in agitated N6 liquid medium containing high concentrations of 2,4-D, Ficoll and potato extract. Microspore division within the anthers and subsequent embryogenic development were obtained in medium containing high amounts of zeatin, NAA and BAP [benzyladenine]. Once embryoids were formed in the liquid medium, they produced secondary embryoids from the scutellum. Plants were obtained on transfer to Murashige & Skoog medium containing BAP and NAA. The ratio of green plants to albinos was 1 : 8.7.

320 KOTHARI, SL; CHANDRA, N. 1988. **Somatic embryogenesis and plant regeneration from seed callus of barley (*Hordeum vulgare L.*)**. *Current Science*, 57: 24, 1351-1352; 13 ref.

When seeds of the genotype RD387 were aseptically cultured on MS medium supplemented with 2,4-D (1 to 5 mg/l), callus proliferation was highest at the highest concentrations. After 3-4 weeks, callus was subcultured on medium with 2,4-D at 0.5 mg/l plus kinetin at 0.2 mg/litre. Embryoids differentiated in the callus within 4 weeks. When the 2,4-D was replaced by coconut water (5%) shoot formation occurred. Rooting was accomplished on MS medium with added IBA or NAA.

321 MOHANTY, BD. 1990. **Chromosomal analysis of cultured cells of barley (*Hordeum vulgare L.*): chromosome number variation**. *Cytologia*, 55: 3, 399-404; 20 ref.

Nodular morphogenic calluses derived from embryo, mesocotyl or leaf explants were repeatedly subcultured for 6 months. Wide variation in chromosome number was observed (2n = 5 to 100). Diploid cells (2n = 2x = 14) predominated in all cultures. In an embryo-derived callus, tetraploid (2n = 4x = 28) cells increased significantly after 90 days of culture, but no significant increase of tetraploid cells with age was observed in mesocotyl and leaf calluses. The frequency of aneuploid and high polyploid cells decreased with increasing age of the culture.

322 MOHANTY, BD; GHOSH, PD. 1988. **Somatic embryogenesis and plant regeneration from leaf callus of *Hordeum vulgare***. *Annals of Botany*, 61: 5, 551-555; 28 ref.

Explants obtained from the basal portion of leaves of barley cv. Karan 92 gave rise to callus when cultured on Murashige and Skoog (MS) basal medium supplemented with 2,4-D. Initially the callus was friable, shiny-white and watery but subsequently some compact nodular calluses appeared. The latter were cultured on MS medium containing 0.05 mg 2,4-D and 0.1 mg kinetin/litre and plantlets were generated. Histological studies showed that plantlet regeneration occurred by the formation of somatic embryos. The regenerated plant had the normal diploid chromosome number (2n=14).

323 REDDY, MK; SUBRAHMANYAM, NC. 1985. **Genome relationships between *Hordeum procerum* (6x) and *H. lechleri* (6x)**. *Genetica (Netherlands)*, 66: 1, 53-61; 20 ref.

The meiotic behaviour of chromosomes in interspecific hybrids (2n = 6x = 42) between *H. lechleri* (6x) and *H. procerum* (6x) and in their component haploids was studied. In the F1 hybrids an average of 25 (60%) chromosomes associated at metaphase I, mostly as bivalents. A majority (60%) of PMCs in *H. procerum* haploids (2n = 3x = 21) displayed 21 univalents, and even in the remainder a maximum of only 2 rod bivalents were formed resulting in an average of 0.52 bivalents per cell. In haploids of *H. lechleri* (2n = 3x = 21), 30% of chromosomes paired. The sum of the chromosomal associations in the component haploids represented only 17%, far below the observed frequency (60%) in the hybrids. Thus, it is thought that the pairing displayed in the interspecific hybrids was mostly allosyndetic and suggestive of 2 genomes being common in these species.

Millets

324 Biotechnology in tropical crop improvement. *Proceedings of the International Biotechnology Workshop*. (ICRISAT Center, Patancheru, India: 1987: January 12-15). International Crops Research Institute for the Semi-Arid Tropics. Patancheru, India. 152 p.

The current state of genetic manipulation is discussed in papers on gene vectors for plant transformation, direct and indirect gene transfer using pollen as carriers of exogenous DNA, plant molecular breeding, potential of complementary DNA techniques for detection of viruses, potential of enzyme-linked immunosorbent assay for detecting viruses, fungi, bacteria, 'microplasm-like' organisms, mycotoxins and hormones, somaclonal and gametoclonal variation, manipulation of cell and protoplast culture in rice and *Brassica* species, tissue culture approaches to pigeon pea improvement, experiments on protoplast fusion in *Trifolium*, wide hybridization in legumes at ICRISAT, and selecting cultivars for resistance to high and low temperatures. In a section devoted to products and uses, bioenergetic considerations in the genetic improvement of crop plants, biotechnological applications in cereals (particularly sorghum and pearl millet) and legumes, and the utilization of the crops are discussed.

325 AGARWALA, R; TILAK, KVBR. 1988. **Colonization of *Azospirillum* in leaves of *Eleusine coracana* and *Setaria italica***. *Zentralblatt fur Mikrobiologie*, 143: 7, 533-537; 15 ref.

The colonization of *Azospirillum* in leaf tissues of finger millet (*Eleusine coracana*) and Italian millet (*Setaria italica*) is reported here.

326 CHAUDHARY, RN; SHARMA, VK. 1987. **Parasitization in diapausing larvae of *Chilo partellus (Swinhoe)* by *Apanteles flavipes (Cameron)*.** *Indian Journal of Ecology*, 14: 1, 155-157; 4 ref.

The rate of parasitism of diapausing larvae of the pyralid *Chilo partellus* by the braconid *Apanteles flavipes* was investigated using larvae collected from sorghum fields in Uttar Pradesh, India, in the winters of 1981-82 and 1982-83. The maximum rate of parasitism occurred in October to November in both years (21.0 and 36.7%, respectively) and then declined during December to zero in January. It is suggested that the abrupt reduction in the rate of parasitism during the first 2 weeks of December may have been caused by a fall in the minimum air temperature. The latest an adult parasitoid was observed to emerge was 26 February in 1983. The results showed that *A. flavipes* did not undergo diapause along with its host. The development times of the parasitoid were compared under atmospheric and constant conditions of 28±1°C and 60-80% RH. It is suggested that *A. flavipes* could be reared during the winter season and released at an appropriate time to control *C. partellus* in the kharif season.

327 CHAUDHRY, MUHAMMAD B; HUSSAIN, MEDHET K. 1981. **Fodder yield potential in sorghum-Sudangrass F1 hybrids and their ratoon crop.** *Nucleus, Pakistan*, 18: 3, 47-53; 24 ref.

All possible hybrid combinations were made between four cytoplasmically male-sterile sorghum varieties and four Sudan grass varieties. Compared with their parents, the hybrids showed improved vigour for fodder yield and seven yield-related and quality traits. Like Sudan grass, the hybrids could be ratooned.

328 COX, TS; FREY, KJ. 1983. **Experimental introgression of wild germplasm into cultivated sorghum in India**. *Agronomy Abstracts*, 60. Madison, Wisconsin, USA; American Society of Agronomy.

Populations derived from wild *Sorghum arundinaceum* X cultivated *S. bicolor* crosses and backcrosses to *S. bicolor* deviated significantly from the expected change in genetic variance with backcrossing. Genetic variance for grain yield reached a maximum in the BC1 or BC2, depending on the cross. Generation means also deviated from the expected linear increase. An epistatic model involving gene regulation is put forward to explain these results.

329 COX, TS. 1983. **Introgression of wild germplasm into cultivated sorghum**. *Dissertation Abstracts International, B*, 44: 6, 1674B.

Populations of BC0F2 to BC4F2 lines from six wild X cultivated crosses were evaluated for grain yield and other agronomic and morphological traits in south central India. Mean grain yield and plant height changed nonlinearly with backcrossing and genetic variances for grain yield, plant height and number of days to flowering were highest in the BC1 or BC2. Epistasis is thought to be the most plausible explanation of the results. Lines exceeding the recurrent parent in grain yield by an average of 15% occurred in four crosses.

330 COX, TS; HOUSE, LR; FREY, KJ. 1984. **Potential of wild germplasm for increasing yield of grain sorghum**. *Euphytica*, 33: 3, 673-684; 11 ref.

Each of 2 cultivated sorghum lines (the dwarf Combine Kafir 60B (CK60B) and RS/R/A2725) was crossed with accessions of 3 wild African species (*S. virgatum*, *S. arundinaceum* and *S. verticilliflorum*). Backcross populations containing 3 to 50% wild germplasm were evaluated in south central India for grain yield and 9 related traits. No individual BC0F2 to BC2F2-derived lines were transgressive segregates for high grain yield. Only 1.5% of all BC3F2 or BC4F2-derived lines were transgressive segregates, with a 26% higher mean grain yield than their respective recurrent parents. The 10 highest-yielding BC2F2 to BC4F2-derived lines per cross having parent CK60B yielded an average of 14% more than CK60B However, increased yield was associated with increased plant height. The highest-yielding lines from RS/R/A2725 X *S. virgatum* and RS/R/A2725 X *S. verticilliflorum* were an average of 13.5% higher-yielding than RS/R/A2725, with no change in plant height. Selection increased BC2 mean grain yields by 6 to 27%. Population mean yield, mean yield of selected lines, and frequency of high-yielding lines were highest in the BC4.

331 DANGI, OP; LODHI, GP; NATH, R; RAM, H. 1983. **Genetics of forage characters in sorghum**. *Haryana Agricultural University Journal of Research*, 8: 3, 468-470; 5 ref.

Six characters were studied in the F1-F3 of crosses of the *Sorghum bicolor* varieties IS6090 and HFS566 with *S. roxburghii* and *S. bicolor cv. PJ7R*. Data on the additive, dominance and epistatic gene effects for the characters are tabulated.

332 DINESHKUMAR, SP; SHASHIDHAR, VR; RAVIKUMAR, RL; SEETHARAM, A; GOWDA, BTS. 1992. **Identification of true genetic dwarfing sources in foxtail millet (*Setaria italica* Beauv.)**. *Euphytica*, 60: 3, 207-212; 19 ref.

True genetic dwarfs hitherto not reported have been identified in foxtail millet. The dwarfs as a group distinguished themselves from the talls in having an altered constellation of characters. Morphological differences were highly significant for plant height, internodal length and tillering potential. The talls had elongated internodes compared to dwarfs while there was no difference for node number on the main stem, suggesting that short internodes are primarily responsible for dwarfism. The dwarfs also showed slightly higher leaf number per plant, leaf area and harvest index compared to talls. The dwarfs were insensitive to exogenous GA3 application indicating the GA3 synthesis is not impaired. This suggests that dwarfing gene sources presently identified are true genetic dwarfs and their behaviour is similar to dwarfs derived from Norin 10 in wheat and Dee-geo-woo-gen in rice. The superior morphological frame makes these dwarfs ideal as far as plant type is concerned and offers considerable potential for breeding high yielding foxtail millets.

333 EAPEN, S; GEORGE, L. 1990. **Somatic embryogenesis and plant regeneration in inflorescence segments of *Sorghum versicolor*.** *Maydica*, 35: 1, 55-58; 9 ref.

Embryogenic callus cultures were initiated from immature inflorescences on MS basal medium supplemented with 2 mg of 2,4-D, 2,4,5-T or picloram in combination with 0.1 mg zeatin per litre. The best response was obtained from 4-8 cm long inflorescences. The somatic embryos developed into plants on MS medium supplemented with 0.1 mg kinetin, benzyladenine, 6 gamma-gamma-dimethyl allyl amino purine or zeatin per litre. Cytological analysis of the regenerated plants revealed a wide range of ploidy (2n = 10 to 40).

334 GEORGE, L; EAPEN, S. 1989. **Callus growth and plantlet regeneration in some Indian cultivars of sorghum.** *Current Science*, 58: 6, 308-310; 9 ref.

Stem and leaf-base explants of 7 cultivars were used. The stem explants died. The leaf-base explants produced callus but only produced buds in 3 cultivars, CO23, TNS24 and TNS25. Callus was also obtained from the seeds of CO23.

335 GEORGE, L; EAPEN, S; RAO, PS. 1989. **High frequency somatic embryogenesis and plant regeneration from immature inflorescence cultures of two Indian cultivars of sorghum (*Sorghum bicolor L. Moench*).** *Proceedings of the Indian Academy of Sciences, Plant Sciences*, 99: 5, 405-410; 9 ref.

Calluses were produced from immature inflorescences of TNS25 and SPV346 cultured on MS medium supplemented with 2 mg 2,4-D and 0.1 mg zeatin/litre. Inflorescences of 10-25 mm in length were the most responsive. The greatest average number of somatic embryoids/culture was obtained upon transfer of calluses to media containing kinetin + TIBA or zeatin + TIBA. Development of embryoids into complete plantlets was confined to media supplemented with high concentrations of kinetin or benzyladenine.

336 JAYARAJ, S. 1987. **Resurgence of sucking pests. Proceedings of national symposium.** Tamil Nadu Agricultural University, Coimbatore. 272 p.

The 41 contributions in this book were presented at a national symposium on the resurgence of sucking pests, held in Coimbatore, India, and are devoted to the incidence, injuriousness, biology and control of pests of various crops, including rice, sugarcane, sorghum, *aubergines, cucurbits*, chillies [*Capsicum*] and cotton. Topics dealt with in the various papers include the resurgence of insecticide resistance, varietal susceptibility, the effects of insecticides on natural enemies of pests (with special reference to their effects on resurgence of pests), and recent outbreaks of mealybugs and their biological control. Author and subject indexes to the whole volume are provided.

337 KUMAR, LS; GUPTA, VS; RANJEKAR, PK. 1990. **Identification and partial characterization of two species-specific repeat families in the great millet (*Sorghum vulgare, Poaceae*) genome.** *Plant Systematics and Evolution*, 171: 1-4, 249-257; 40 ref.

The 1.4 kb XbaI and the 1.3 kb EcoRI repeat families in *S. vulgare* [*S. bicolor*] were partially characterized with respect to their genomic distribution and their homology with the EcoRI and XbaI families of 5 other millet DNAs (from *Setaria italica*, *Panicum miliare*, *Echinochloa frumentacea*, *Eleusine coracana* and *Pennisetum americanum*). Digestion of *S. vulgare* DNA using increasing amounts of the 2 enzymes showed that these 2 families are dispersed in the genome. The hybridization of these 2 families to the genomic digests of *S. vulgare* indicated that they are arranged in a clustered and disorganized manner. Similarly, hybridization with the EcoRI and XbaI digests of the 5 other millet DNAs revealed the species-specific nature of these 2 repeat families. The latter also hybridized to the total repetitive fraction of *S. vulgare* isolated at a highly stringent temperature of 75°C, suggesting that the members of these 2 families are probably largely homogeneous.

338 KUMARAVADIVEL, N; RANGASAMY, SRS. 1991. **A protocol for overcoming phenolic and tannin exudations in sorghum in vitro culture**. *Sorghum Newsletter*, 32, 14; 6 ref.

Phenolic and tannin exudates in explants of sorghum inhibit callus induction and multiplication during in vitro culture. This paper details a protocol that has been established to overcome tannin exudation for explants of young leaves and immature inflorescences of the cultivars CO26, CO27, CO11 and K7. Injury to the meristematic regions of explants is avoided since they are covered by the outer whorls of leaves while being sterilized with 0.1% mercuric chloride. Pre-soaking with liquid medium washes out the tannins and, along with the auxins and cytokinin, penetrates the cell and accelerates callus induction and production of more embryogenic calluses.

339 NAYAK, P; SEN, SK. 1989. **Plant regeneration through somatic embryogenesis from suspension cultures of a minor millet, *Paspalum scrobiculatum***. *Plant Cell Reports*, 8: 5, 296-299; 18 ref.

Compact, friable and embryogenic calluses were initiated from immature inflorescences and young leaf bases of one-week-old seedlings cultured on MS medium supplemented with 2,4-D. A stable, embryogenic suspension culture was initiated from these calluses and maintained in a liquid version of the same MS medium. Embryogenic calluses and somatic embryos were obtained by plating suspension culture cells onto semi-solid medium containing 2,4-D. Complete, normal plantlets developed on 2,4-D free medium at a high frequency from somatic embryos. NAA and BAP [benzyladenine] in the medium promoted plant development.

340 NAYAK, P; SEN, SK. 1991. **Plant regeneration through somatic embryogenesis from suspension culture-derived protoplasts of *Paspalum scrobiculatum* L.** *Plant Cell Reports*, 10: 6-7, 362-365.

341 PRABHU, MSC; VENKATASUBBAIAH, P; SAFEEULLA, KM. 1984. **Changes in total phenolic contents of sorghum callus resistant and susceptible to downy mildew**. *Current Science*, 61: 6, 271-273; 11 ref.

Callus infected by *Peronosclerospora sorghi* contained more phenolics than healthy tissues. As the tissue aged, total phenolics increased in both resistant and susceptible cultivars. Young callus of a resistant cultivar contained much greater amounts of phenolics than that of a susceptible one. These results suggest that these cultures may be utilized to study the biochemical changes occurring in host-parasite reactions of obligate parasites.

342 RAJASEKHAR, VK; MUKHERJEE, S GUHA; SOPORY, SK. 1983. **The effects of delta-aminolaevulinic acid and inhibitors of RNA and protein synthesis on phytochrome mediated chlorophyll accumulation in *Sorghum bicolor***. *Journal of Experimental Botany*, 34: 148, 1444-1454; 46 ref.

In 5-day-old etiolated sorghum seedlings, 12 h of darkness after 5 min in red light eliminated a lag before the accumulation of chlorophyll in subsequent white light. Increasing the dark period to 24 or 36 h increased the chlorophyll accumulation rate in the later stages of greening. Exogenous delta-aminolaevulinic acid neither completely removed the lag nor increased the chlorophyll accumulation rate. *Cycloheximide* at 25 μg/ml or 6-methyl purine at 5 μg/ml given continuously or only until the 12 h dark period following the red light irradiation, restored the lag and decreased the chlorophyll accumulation rate. D-threo-chloramphenicol at 400 μg/ml also decreased the chlorophyll accumulation rate but did not restore the lag. Addition of these inhibitors even 12 h after red light irradiation, decreased the chlorophyll accumulation rate. Rifampicin did not have such effects.

343 RAJASEKHAR, VK; MUKHERJEE, S GUHA; SOPORY, SK. 1983. **Time dependence of phytochrome-mediated carotenoid and chlorophyll synthesis in *Sorghum bicolor L.***. *Annals of Botany*, 52: 2, 159-163; 18 ref.

In 5-day-old etiolated sorghum seedlings, red light irradiation for 1 s enhanced carotenoid and chlorophyll accumulation, and 5 min of red light treatment saturated the photoresponse. The degree of red/far-red photoreversibility of carotenoid accumulation was dependent on the age of the plant. No significant escape from far-red reversibility was observed up to 30 min after the onset of a saturating red light pulse in 5-day-old etiolated seedlings. Thereafter, the escape was relatively fast and completed within 180 min.

344 RAMAN, VS. 1983. **Inheritance of leaf-stripiness grain sorghums**. *Sorghum Newsletter*, 26, 83.

White-striped plants of *Sorghum roxburghii* accession AS7657, which has unstable plastids, gave mainly striped progeny with a few green or white individuals. When crossed as male with green plants (AS7657, *S. nervosum* and *S. splendidum*), striped AS7657 gave all-green F1s, while as female crossed with green AS7657 and *S. subglabrescens* it gave a mainly green F1 with a

few striped or white plants; the F2s in both types of cross segregated 15 green : 1 striped. Transmission of the chloroplast effect via the maternal cytoplasm and suppression of plastid mutation by dominant nuclear genes are suggested.

345 RAMESH, B; REDDY, GM. 1984. **Maize X sorghum hybridization**. *Maize Genetics Cooperation Newsletter*, No. 58: 100-101.

A total of 923 reciprocal controlled pollinations (480 maize X male- fertile sorghum and 443 male-sterile sorghum X maize) were made by conventional methods. Of 67 grains obtained, only 2, from the cross SC440 maize (female) X CSH5 sorghum (male), were hybrids. The plants obtained from these grains did not give viable pollen and were morphologically more similar to maize than to sorghum.

346 RAO, AM; KISHOR, PBK. 1989. **In vitro plant regeneration potential from callus cultures of grain sorghum**. *Current Science*, 58: 12, 692-693; 9 ref.

Seeds of 3 *Sorghum bicolor* cultivars were inoculated onto supplemented Linsmaier and Skoog medium and induced to form callus. Calluses were then transferred to supplemented MS medium. Shoot and root formation was induced in 45-day-old calluses with 5-10 mg BAP [benzyladenine]/litre, 1 mg 2,4-D/litre and either 3% sucrose or 0.2 mg NAA/litre + 2.5% sucrose. Shoot regeneration was most frequent in IS18417, followed by IS1054 and IS18758. Regenerated shoots developed roots on MS medium supplemented with 1 mg NAA/-litre and 2% sucrose.

347 REDDY, LA; VAIDYANATH, K. 1990. **Callus formation and regeneration in two induced mutants of foxtail millet (*Setaria italica*)**. *Journal of Genetics and Breeding*, 44: 2, 133-138; 14 ref.

Callus was initiated from mature seeds and immature glumes of mutants and their parental genotypes at different developmental stages on LS (Linsmaier & Skoog) medium supplemented with 2 mg 2,4-D/litre. Callus induction rates ranged from 75.7% for the early maturing mutant PGSE-L123EM to 94.7% for the extreme dwarf mutant 1SE464ED. In all cases, glumes isolated at the PMC stage gave markedly better callus induction than those isolated at the uninucleate or binucleate stage. Plantlet regeneration from glumes at the PMC stage was best on medium containing 4 mg kinetin/litre. When these glumes were used, 1SE464ED gave a higher regeneration frequency (47.2%) than its source genotype (30.9%) whereas the converse was true for PGSE-L126EM (30.0% vs 47.2%) It was concluded that mutants differ from their source genotypes in callus induction and plant regeneration capabilities.

348 SALIM, M; MASUD, SA; KHAN, AM. 1987. ***Orius albidipennis (Reut.) (Hemiptera: Anthocoridae)* - a predator of cotton pests**. *Philippine Entomologist*, 7: 1, 37-42; 14 ref.

O. albidipennis, a predator of cotton pests in Pakistan, was surveyed in the major cotton-growing areas of the Punjab region in 1979. In the early stages of the crop, the anthocorid was found mostly on the lower surface of the leaves, but later it was confined to the flowers. It remained continuously in the cotton agroecosytem, transferring to alternative food plants of cotton pests in the off-season. Populations varied from field to field in relation to the use of pesticides, cultural practices and cropping systems. *O. albidipennis* was recorded on 8 other plants, but maize, sorghum and *Althaea rosea* [*Alcea rosea*] appeared to be the most important in ensuring its survival from one cotton season to the next. The feeding efficiency of the predator was recorded in the laboratory on immature stages of *Aphis gossypii*, the cicadellid *Amrasca devastans*, the aleyrodid *Bemisia tabaci*, *Tetranychus spp.* and *Thrips spp.* and the eggs and 1st-instar larvae of the gelechiid *Pectinophora gossypiella* and the noctuids *Earias insulana*, *Spodoptera litura* and *Heliothis armigera* [*Helicoverpa armigera*]. Adults caused higher mortality of these pests than nymphs. Several plants, including *Alcea rosea*, *Abutilon spp.* and *Hibiscus esculentus* [okra], harboured both prey species of *O. albidipennis* and cotton pests. It is suggested that they should not be allowed to grow near cotton.

349 SHAH, CK. 1983. **Morphohistochemical studies on the embryos of some monocotyledons**. *Phytomorphology*, 33: 1/4, 62-73; 34 ref.

Morphohistochemical studies on the embryos of rice, sorghum, maize, *Coix lacryma-jobi* and some other monocotyledons are described.

350 SHARMA, VANDANA; KOTHARI, SL; CHANDRA, N. 1989. **In vitro regeneration, field transfer of plantlets and growth to maturity of plants of *Sorghum bicolor (L.) Moench***. *Current Science*, 58: 10, 586-588; 8 ref.

Embryo-derived calluses grown on supplemented MS media produced somatic embryos and shoots. A medium supplemented with cytokinin and auxin produced more regenerative calluses than one with auxin alone. Plantlets were successfully transferred to soil.

351 SREENIVASAN, TV; SREENIVASAN, J. 1984. **Cytology of *Saccharum* complex from New Guinea, Indonesia and India**. *Caryologia*, 37: 4, 351-357; 9 ref.

Study of meiosis and chromosome number in 30 clones from *Saccharum*, *Sclerostachya fusca* and *Narenga porphyrocoma* revealed the existence of *Saccharum* hybrid swarms in areas of species diversity. A new cytotype of *Sclerostachya fusca* with 2n = 34 is reported. A naturally occurring intergeneric hybrid between *Saccharum spontaneum* and sorghum has been found among the Indian collections. Tabulated data are presented on place of collection and on chromosome numbers of the clones.

Finger millet

352 BASAVARAJA, GT; SHERIFF, RA. 1992. **Formulation of selection indices in finger millet (*Eleusine coracana Gaertn.*)**. *Indian Journal of Genetics and Plant Breeding*, 52: 2, 199-202.

353 EAPEN, S; GEORGE, L. 1990. **Influence of phytohormones, carbohydrates, aminoacids, growth supplements and antibiotics on somatic embryogenesis and plant differentiation in finger millet**. *Plant Cell, Tissue and Organ Culture*, 22: 2, 87-93; 23 ref.

Cultured caryopses of *Eleusine coracana* produced callus from shoot apices or mesocotyls depending on picloram concn and combination of cytokinins in MS basal medium. On subsequent subcultures, numerous somatic embryos differentiated from the callus on MS medium supplemented with picloram and kinetin. The embryos germinated into complete plants on medium without phytohormones. When different carbohydrates were tested, basal medium containing glucose and sucrose produced the highest frequency of germinating somatic embryos. Supplementation of MS basal medium with a variety of amino acids, osmotic agents and growth supplements had an adverse effect on the germination of embryos. Incorporation of different antibiotics such as carbenicillin, cefotaxime and streptomycin sulphate enhanced plant differentiation from somatic embryos. Cytological analysis of regenerated plants showed normal diploid chromosome number in their root tips.

354 GEORGE, L; EAPEN, S. 1990. **High frequency plant-regeneration through direct shoot development and somatic embryogenesis from immature inflorescence cultures of finger millet (*Eleusine coracana Gaertn.*)**. *Euphytica*, 48: 3, 269-274; 23 ref.

Direct development of shoots from cultured inflorescence segments occurred on MS medium supplemented with 2,4-D in combination with zeatin. Inflorescences with well-developed spikelets differentiated at a low frequency (<5%) from callus cultures initiated on media supplemented with 2,4-D in combination with zeatin, coconut water or picloram + kinetin. Somatic embryogenesis was also induced in callus cultures growing on MS supplemented with picloram + kinetin at the end of 4 passages. A sucrose concentration of 3% was found to be most effective for plantlet differentiation. The majority of regenerated plants were diploid and were shorter with an increased number of tillers compared to the control.

355 HIREMATH, SC; SALIMATH, SS. 1992. **The 'A' genome donor of *Eleusine coracana (L.) Gaertn. (Gramineae)***. *Theoretical and Applied Genetics*, 84: 5-6, 747-754; 20 ref.

In an attempt to discover A and B genome donor(s) to finger millet, *E. coracana*, or its progenitor species, *E. africana* [*E. indica*] (both allotetraploid 2n = 4x = 36), five diploid species, *E. indica*, *E. floccifolia*, *E. multiflora*, *E. tristachya* and *E. intermedia*, were crossed to finger millet and its progenitor taxon. Crosses were successful only with *E. coracana*. Three combinations of triploid hybrids, *E. coracana* X *E. indica*, *E. coracana* X *E. floccifolia* and *E. coracana* X *E. multiflora*, were obtained and analysed. Meiotic behaviour was perfectly normal in parental species. The regular number of 18 bivalents in *E. coracana*, 9 bivalents in *E. indica*, *E. intermedia*, *E. tristachya* and *E. floccifolia* and 8 bivalents in *E. multiflora* were invariably noticed. In *E. coracana* X *E. indica* hybrids a mean chromosome pairing of 8.84I + 8.80II + 0.03III + 0.10IV per cell was found. About 86.5% of the cells showed the typical 9I + 9II configuration, suggesting that *E. indica* (AA) is one of the diploid genome donors to cultivated species *E. coracana*. A mean chromosome pairing of 11.08I + 7.63II + 0.16III + 0.04IV per cell was found in *E. coracana* X *E. floccifolia* hybrids. Two to ten bivalents and varying numbers of univalents were seen in 55% of the cells. About 45% of the cells showed the 9I + 9II configuration. Various evidence suggests that perennial *E. floccifolia* is a primitive member of the A genome group of *Eleusine* species, and it may not be a genome donor to *E. coracana*. In *E. coracana* X *E. multiflora* hybrids (2n = 26) mean chromosome pairing of 21.45I + 1.97II + 0.13III + 0.04IV per cell was found. About 91% of the cells were observed to have 20-26 univalents. Only a small percentage of the cells contained bivalents or multivalents. This pairing behaviour

indicates that *E. multiflora* lacks genomic homology with the A or B genome of *E. coracana*. Genomically *E. multiflora* is a distinct species and a genomic symbol of C is assigned to it. Identification of B genome donor species to cultivated millet *E. coracana* remains elusive.

356 KUMAR, LS; SIVARAMAN, L; RANJEKAR, PK. 1992. **Genome turnover in great millet and related millets (Poaceae)**. *Plant Systematics and Evolution*, 179: 1-2, 155-165; 27 ref.

Based on optical reassociation studies of total nuclear DNAs at 55, 62, 69 and 75°C, it is concluded that repeat families in great millet (*Sorghum bicolor*), little millet (*Panicum miliare* [*P. sumatrense*]), barnyard millet (*Echinochloa frumentacea*) and finger millet (*Eleusine coracana*) are heterogeneous while those of foxtail millet (*Setaria italica*) are homogeneous. In great millet, almost one third of the sequences that behave as single copy at standard conditions are actually 'fossil' repeats. Such repeats are not a prominent feature of the genomes of the other 4 millets. The ratios of sequence complexities of repeats isolated at 75°C to those isolated at 55°C are 2.2, 3.5, 81 and 0.3 in case of little millet, finger millet, foxtail millet and great millet, respectively. On the basis of the above 3 observations, it is suggested that among these millets, the rate of turnover of the genome of foxtail millet is the slowest while that of great millet is the fastest. Such comparative estimates of differences in the turnover rates of genomes of related species are expected to generate useful data about the evolution of genomes.

357 SINHA, PK. 1983. **Identification of *Eleusine indica subsp. africana* from Almora**. *Crop Improvement*, 10: 1, 61-64; 5 ref.

Eight morphological characters were studied in plants identified as *E. indica subsp. africana* (2n = 36). The 41 plants were assigned to 3 groups: one group resembled *E. indica* subsp. indica, one group resembled *E. coracana subsp. coracana* and the other group was intermediate between the two species. It is suggested that hybridization may have taken place between *E. indica subsp. africana* and *E. coracana subsp. coracana*.

358 SIVADAS, PRASANNA; KOTHARI, SL; CHANDRA, N. 1990. **High frequency embryoid and plantlet formation from tissue cultures of the finger millet *Eleusine coracana (L.) Gaertn***. *Plant Cell Reports*, 9: 2, 93-96; 11 ref.

Compact nodulated embryogenic callus differentiated from seeds cultured on MS medium with 2,4-D (1.0 and 3.0 mg/litre). This callus was maintained on a medium with a lower level of 2,4-D (0.2 mg/litre) and at every subculture had some preexisting embryoids in it. With this method of subculture the callus retained its morphogenic potential for 4 years. Following transfer to media with different levels of auxins and cytokinins, the callus showed various patterns of growth and morphogenesis. Embryoids were germinated to form plantlets which were transferred to the field. Shoot buds also differentiated from the whole surface of the embryoid or from the flattened meristemoids.

359 UPADHYA, A; GOVARDHAN, LK; VEERABHADRAPPA, PS. 1985. **Esterases as genetic markers in finger millet**. *Journal of the Science of Food and Agriculture*, 36: 5, 319-325; 23 ref.

A total of 21 *Eleusine coracana* varieties were screened for esterase activity colorimetrically and electrophoretically using 1-naphthyl acetate and acetylthiocholine chloride as substrates. Purna, a variety with a brown testa, Hamsa, with a white testa, their hybrids with brown or white testas, all originating from India, the 4 African varieties and the 4 Indian X African hybrids, all with brown testas, exhibited hydrolysing activity for 1-naphthyl acetate and showed 6, 5, 6, 5, 8 and 8 esterolytic bands, respectively, on gel electrophoresis. The varieties and hybrids with white testas did not possess any acetylthiocholinesterase activity, while all those with brown testas did, the African varieties and Indian X African hybrids having greater activity than the Indian varieties. It is concluded that variation in esterase isoenzymic pattern and acetylcholinesterase activity provides a useful genetic marker for identifying *E. coracana* varieties.

Pearl millet

360 CHANDA, SV; JOSHI, AK; VAISHNAV, PP; SINGH, YD. 1988. **Enzymes of ammonia assimilation and transamination in relation to hybrid vigour in pearl millet (*Pennisetum americanum L. Leeke*)**. *Journal of Agronomy and Crop Science*, 160: 2, 125-131; 37 ref.

The ammonia assimilation enzymes glutamate dehydrogenase, glutamine synthetase [glutamate-ammonia ligase] and glutamate synthase, together with glutamate oxaloacetate transaminase [aspartate aminotransferase] and glutamate pyruvate transaminase [alanine aminotransferase] were assayed in the topmost fully-expanded leaf of the hybrid BJ104 and its parents J104 and 5141A at intervals throughout the growth period. The ammonia assimilation enzymes varied markedly in activity during

development, these trends differing among genotypes; the hybrid equalled or exceeded the better parent (J104) in ammonia assimilation enzyme activity. Activities of the transaminases, however, were only slightly higher in the hybrid than in the worse parent (5141A). From a survey of the literature, it is proposed that there can be no universal biochemical criterion of hybrid vigour, but that parents should be selected according to their rate limiting steps so as to produce complementation in the hybrid.

361 DHINDSA, HS; CHAHAL, SS. 1986. **Development of ergot sclerotia on in vitro cultured spikelets of pearl millet**. *Annals of Biology*, 2: 1, 67-71; 12 ref.

Spikelets of the *Pennisetum americanum cv. PSB-8* excised from inflorescences at the boot stage and cultured on Murashige & Skoog's medium produced stigmas after 7 d. Stigmas inoculated with conidia of *Claviceps fusiformis* withered within 2.5 d. Honey dew was produced after 5.5 d and sclerotia after 14 d in 72 and 71.2% of spikelets, respectively. The characteristics of axenic cultures from these sclerotia were similar to those obtained from sclerotia collected from the field.

362 MANIVASAKAM, P; PALANISAMY, S; PRASAD, MN; ARJUNAN, G; APPADURAI, R. 1986. **Development of non-restorer pearl millet lines resistant to downy mildew**. *Madras Agricultural Journal*, 73: 5, 258-262; 4 ref.

The cytoplasmic male sterility maintainer (non-restorer) inbred lines 732B, J126D2B1, L111B and 5141B were used as recurrent maternal parents in crosses and backcrosses with 29 downy mildew [*Sclerophthora macrospora*] resistant lines. Of the 105 non-restorer lines produced, 76 acted as maintainers to varying degrees when crossed with male-sterile lines 732A and 81A and exhibited stability for most morphological characters, together with resistance to the pathogen. Lines developed using 5141B were the least resistant.

363 RAO, AS; MENGESHA, MH; REDDY, CR. 1989. **Identification, characterization and geographic distribution of male-sterility restorer and maintainer lines from diverse pearl millet germplasm**. *Euphytica*, 40: 1-2, 155-159; 18 ref.

A total of 428 accessions of *Pennisetum americanum*, from 12 countries, were crossed with a male-sterile line, 5141A. The F1 hybrids were classified as male-fertile or male-sterile on the basis of seed set of bagged ear heads and morphology. Of them, 20.3% were classified as male-fertile, 7.5% as male-sterile, 65.9% as segregating from male-fertile or sterile lines and 6.3% as male-fertile in the rainy season and male-sterile in the post-rainy season. Maintainer lines were from 6 countries but were concentrated in India. Maintainer lines differed from each other in several morphological and agronomic characters.

364 SUBBARAO, MV; SAIDESWARARAO, Y; MANGA, V. 1989. **Genetics of five seed esterase isozymes in pearl millet**. *Plant Breeding*, 102: 2, 133-139; 23 ref.

Inheritance and linkage relationships of seed esterase isoenzymes were studied in 6 *Pennisetum americanum* hybrids and the 4 inbreds from which they were derived, using PAGE. The zone of enzyme activity was resolved into 5 bands. The presence of a band showed complete dominance over its absence. Each of the bands 1 to 4 was under the control of a single gene. Band five was found to be controlled by 3 independent loci with duplicate gene action. Loci for Est1, Est3 and Est4 were found to be linked. Est2 was independent of this linkage group.

365 SUJATHA, M; SUBRAHMANYAM, NC. 1991. **Characterisation of nuclear gene controlled yellow stripe mutant of *Pennisetum glaucum (L.) R.Br.***. *Plant Science (Limerick)*, 73: 1, 55-64.

366 THAKUR, RP; RAO, VP. 1988. **Effectiveness of ethrel as a male gametocide in pearl millet and its influence on ergot**. *Plant Breeding*, 101: 2, 107-113; 20 ref.

In field and greenhouse experiments, ethrel [ethephon] was tested for its male gametocidal effects on *Pennisetum americanum* and its subsequent effects on *Claviceps* development. Application at 2000 p.p.m. at the late booting or early protogyny stages was the most effective for inducing male sterility in the hybrid BJ104. Female fertility in a male-sterile line was not affected by treatment. Ethrel at 2000 p.p.m. applied at the late booting stage resulted in partial panicle exsertion, and reduced plant height and panicle length. In vitro, ethrel (2000 p.p.m.) completely inhibited pollen germination but did not affect germination of conidia of *C. fusiformis*. In lines differing in resistance, ergot resistance or susceptibility was not affected, probably because ethrel could not induce complete male sterility.

367 VIRK, DS; BRAR, JS; MANGAT, BK. 1993. **Cytoplasmic differentiation using near-isonuclear polycytoplasmic male sterile lines in pearl millet**. *Euphytica*, 67: 1-2, 127-134.

Breeding

368 BRAMEL COX, PJ; ANDREWS, DJ; FREY, KJ. 1986. **Exotic germplasm for improving grain yield and growth rate in pearl millet**. *Crop Science*, 26: 4, 687-690; 7 ref.

Three African strains of *Pennisetum americanum* (a landrace, a weedy accession (*P. americanum subsp. stenostachyum*) and a wild relative (*P. americanum subsp. monodii*)) were crossed with 2 inbreds. Six generations of the crosses were evaluated in the field. Lines with transgressively increased grain yield and growth rate could be selected in all 6 crosses. The wild accession showed the greatest potential for improving growth rate in inbreds, while the other 2 strains were best for improving grain yield.

369 RAO, MK; DEVI, KU. 1989. **Allelic relationship of four male sterility genes and nucleo-cytoplasmic interactions in the expression of male sterility in pearl millet, *Pennisetum americanum (L.) Leeke***. *Theoretical and Applied Genet.*, 77:4, 576-580; 20 ref.

The genes controlling male sterility in lines Vg272, IP482, PDP and IP47 were allelic and the differences between male sterile and fertile phenotypes were due to a single gene. Presence of a dominant gene (Ms) resulted in male fertility and double recessive genes (msms) produced male sterility. Two types of cytoplasm, C-1 and C-2, were identified. The presence of any 2 recessive male sterility alleles in C-1 led to a breakdown of male gametophyte development before the differentiation of an archesporium in the anther and so this was called Arc-type expression while in C-2 cytoplasm degeneration began either during meiosis with the fusion of meiocytes and syncyte formation (Syn-type) or at post-meiotic stages leading to the abortion of microspores before first pollen mitosis (PGM-type). The triggering of the activity of recessive male sterility genes in the C-2 cytoplasm was regulated by 2 nuclear factors, R1 and R2, with duplicate gene action. Recessive R genes produced PGM type expression and the action of these genes was specific to C-2 cytoplasm. Mutation of cytoplasm from C-1 to C-2 and C-2 to C-1 was observed.

370 SUNDARESAN, N; PRASAD, MN. 1986. **New cyto-steriles in pearlmillet through genome substitution**. *Indian Journal of Agricultural Sciences*, 56: 3, 160-163; 7 ref.

A total of 18 new cytoplasmically male-sterile (CMS) *Pennisetum typhoides* [*P. americanum*] lines were developed from a backcrossing programme involving 7 CMS lines and 20 selected inbreds. Data on the designation, source of cytoplasm, height, tillering, panicle characteristics and days to 50% flowering and to maturity are tabulated. Analysis of data on combining ability from crosses with 3 restorer lines revealed a high correlation between hybrid per se performance and specific combining ability (SCA) effects. Hybrids with high per se performance and SCA effects for 5 traits are identified.

Hybridization

371 MAHALAKSHMI, V; BIDINGER, FR; RAO, KP; RAJU, DS. 1992. **Performance and stability of pearl millet topcross hybrids and their variety pollinators**. *Crop Science*, 32: 4, 928-932.

A majority of farmers in the arid and semiarid regions of Africa and South Asia continue to cultivate their local landraces of pearl millet [*Pennisetum glaucum (L.) R. Br.*], rather than improved varieties. The reasons for this preference for local landraces may include their better yield stability and adaptation to environmental stress, although their grain yield potential is often lower than that of the new varieties. This study was conducted to test the hypothesis that the yield potential of such landraces could be improved without seriously affecting their stability and adaptability, by using them as pollinators in topcross hybrids. Three pollinator groups (five accessions per group) reflecting three levels of breeding effort were crossed on two male-sterile lines selected to specifically advance time to flowering and to increase individual grain mass. Topcrosses and their pollinators were evaluated in India, during the rainy season at three locations (ICRISAT Center, 17.50 degrees N, 78.47 degrees E; Anantapur, 14.68 degrees N, 77.62 degrees E; Fatehpur, 27.17 degrees N, 75.13 degrees E) in 1988 and 1989 and at Hisar (29.15 degrees N, 75.73 degrees E) in 1989, and during the dry season in irrigated and stress conditions at ICRISAT also in 1988 and 1989. Mean grain yields ranged from 66 to 477 g m-2. The adaptability, stability, and responsiveness of the topcrosses and their pollinators were compared using joint regression analysis. Analyses of adaptability, based on the predicted grain yield of topcrosses and their pollinators in two low yielding environments, indicated that the topcrosses were either equal or superior to their pollinators. Analysis of stability based on the deletions from regression indicated that the topcrosses were either as stable, or more so than their pollinators. Analyses of responsiveness, as measured by the regression coeffi-

cient, indicated that the topcrosses were more responsive to improved environmental conditions than their pollinators. The results suggest that rapid improvement in adapted landraces is possible through their use as topcross hybrids in pearl millet.

372 NATARAJARATNAM, N; CHANDRASEKHARAN, P. 1983. **Physiological basis of heterosis for green matter and dry matter production in the hybrid grass, TNAU CN 2.** *Precongress scientific meeting on genetics and improvement of heterotic systems*. (Coimbatore, India: Tamil Nadu Agricultural Univ., Coimbatore 641 003, India. p. 21.

Studies on the hybrid TNAU CN2, which was bred from a cross between *Pennisetum americanum* and *P. purpureum*, indicated that heterosis for yield is due to simultaneous heterosis for leaf number, tiller number and leaf area. Photosynthetic rate, phosphoenolpyruvate carboxylase activity and nitrate reductase activity were higher in the hybrid than in its parents. More assimilates were diverted to leaves in the hybrid than in its parents.

373 RAO, MK; KUMARI, KA. 1984. **The behaviour and effects of B chromosomes in the embryo and endosperm of pearl millet, *Pennisetum americanum (L.) Leeke*.** *Canad. J. of Gen. and Cytol.*, 26:1, 18-24

Crosses of plants with a mean number of three B chromosomes per PMC (3B X 3B) and crosses of plants with no B chromosomes (0B X 0B) were studied. B chromosomes had a retarding effect on the rate of endosperm development about the middle of the coenocytic phase (24 h), at the time of and just after cellularization. The increase of endosperm cycle time in 3B versus 0B plants was 27%. The rate of embryo development was similar in both 0B and 3B plants up to 48 h postpollination but was significantly different at 72 h. Here the increase of cycle time in 3B versus 0B plants was 20%. Thus the effect of 3B plants on cell cycle time was greater in both the embryo and the endosperm than has been reported previously for the root tip (13%). Nondisjunction of B chromosomes in both embryo and endosperm started quite early. The mean number of B chromosomes per cell in the endosperm exceeded that of the embryo in all cases, probably owing to a fusion of three nuclei in the former compared with two nuclei in the latter.

374 TALWAR, M; RASHID, A. 1990. **Factors affecting formation of somatic embryos and embryogenic callus from unemerged inflorescences of a graminaceous crop *Pennisetum*.** *Annals of Botany*, 66: 1, 17-21; 14 ref.

Differentiation of somatic embryos of *P. typhoides* [*P. americanum*] depended on auxin concn and the mineral medium. Low levels of 2,4-D in N6 medium, a low ammonium nutrient, favoured the formation of somatic embryos, while on Murashige and Skoog (MS) medium containing high ammonium compact tissues appeared. At higher levels of auxin, irrespective of nutrient medium, compact tissues were formed. The origin of compact tissue on N6 medium could be traced to somatic embryo-like structures. This tissue regenerated into somatic embryos on hormone-free N6 medium whereas on MS medium thalloid structures appeared.

375 ZADOO, SN; AMAR SINGH. 1986. **Recurrent addition of the *Pennisetum americanum* genome in a *P. americanum* X *P. orientale* hybrid**. *Plant Breeding*, 97: 2, 187-189; 7 ref.

P. americanum (2n = 14) was crossed with a diploid cytotype of *P. orientale* (2n = 18) and the interspecific hybrid (2n = 16, comprising 7 chromosomes from *P. americanum* (A) and 9 from *P. orientale* (O)) was backcrossed as female parent to *P. americanum*. PMCs of 13 BC1 plants contained 14 A and 9 O chromosomes. Five BC2 plants obtained through further backcrossing to *P. americanum* had 21 A + 9 O chromosomes, revealing another addition of the *P. americanum* genome. It is considered that the production of unreduced female gametes by the hybrid is responsible for this phenomenon.

Tissue culture

376 BAJAJ, YPS; GUPTA, RK. 1986. **Different tolerance of callus cultures of *Pennisetum americanum L.* and *Pennisetum purpureum Schum.* to sodium chloride**. *Journal of Plant Physiology*, 125: 5, 491-495; 13 ref.

Callus of both species exposed to 0-2% NaCl showed a sharp and sudden decrease in fresh and dry weights at concentrations of 0.2% and above. In *P. americanum* complete growth inhibition occurred at 1% and death at 2% NaCl, but some *P. purpureum* callus appeared tolerant of 2% NaCl. Callus tolerant of 0.5% NaCl was selected in both species. Plants (showing a range of morphological variability) were regenerated from such callus in *P. purpureum*; in *P. americanum*, the callus regenerated only roots, though embryogenesis was occasionally observed.

377 BAJAJ, YPS. 1988. **Elephant grass, napier grass (*Pennisetum purpureum Schum.*).** *Biotechnology in agriculture and forestry 6. Crops II*/edited by YPS Bajaj. Berlin: Springer-Verlag, p. 470-481; 27 ref.

Tissue culture techniques for the species are described with particular emphasis on the application of these methods for screening for salt tolerant genotypes. An in vitro study which indicated that *P. purpureum* is more salt tolerant than *P. americanum*.

378 PARBHU, MSC; SAFEEULLA, KM; SHETTY, HS. 1983. **Tissue culture technique to demonstrate the viability of downy mildew mycelium in pearl millet seeds**. *Curr. Science*, 52: 21, 1027-1029; 11 ref.

Mycelium of *Sclerospora graminicola* invading the embryo of pearl millet [*Pennisetum americanum*] seed remained viable in dry seeds, while the viability of mycelium in the pericarp region decreased as the moisture content of the seed declined. When seeds from partially malformed ears were cultured on Murashige and Skoog medium, thin white mycelial growth of the fungus was observed on the callus tissue of 0.1% of the seeds, this being correlated directly to the percentage containing mycelium in the embryonic tissue, as determined by a maceration technique. In some instances the primary callus turned brown in the initial stages, but after subculturing on the same medium, secondary callus developed which showed the downy mildew mycelium. This tissue culture technique is useful for very small seed samples and plantlets may be raised from the callus tissue cultures to save valuable germplasm. It is evident that *S. graminicola* mycelium can remain dormant during unfavourable periods and become active when suitable conditions occur.

379 UPADHYAYA, G; SHIVANNA, MB; PRAKASH, HS; SHETTY, HS. 1992. **A novel approach to the establishment of dual cultures of pearl millet and *Sclerospora graminicola***. *Plant Cell, Tissue and Organ Culture*, 31: 3, 203-206.

Callus culture

380 BAJAJ, YPS; GUPTA, RK. 1992. **In vitro regeneration and somaclonal variation for salt tolerance in pearl millet (*Pennisetum americanum L.*)**. *Plant Tissue Culture*, 2: 2, 103-108.

Callus cultures raised from young unopened inflorescences of Indian cultivars of pearl millet (*Pennisetum americanum L.*) were induced to undergo embryogenesis/ organogenesis to form complete plants. The segments of the inflorescences and the callus raised on various concentrations of sodium chloride (0.1-2%) medium exhibited somaclonal variation for salt tolerance. The initial growth rate at 0 and 0.1% salt was comparable, however a depression on growth was observed at 0.2 to 0.5%. Increase of salt beyond 0.3% caused browning and there was drastic inhibition of growth at 0.5% and death at 3%. Salt tolerant cell lines isolated on a medium containing 0.2% salt regenerated plants, but at 0.5% only rhizogenesis and embryogenesis were observed. The implications of the somaclonal variation for salt tolerance in pearl millet improvement are pointed out.

381 DAS, N; MISRA, M; MISRA, AN. 1990. **Sodium chloride salt stress induced metabolic changes in callus cultures of pearl millet (*Pennisetum americanum L. Leeke*): Free solute accumulation**. *Journal of Plant Physiology*, 137: 2, 244-246.

382 KUMAR, A; ARYA, HC. 1981. **Nature of resistance and susceptibility in vitro in ergot of pearl millet caused by *Claviceps fusiformis Lov.*** *Phytopathologia Mediterranea*, 20: 1, 43-45; 6 ref.

Callus tissues from five varieties of *Pennisetum americanum* ranging from highly susceptible to highly resistant were inoculated. In susceptible varieties, most conidia germinated, and cells were penetrated by hyphae; in resistant varieties, few conidia germinated.

Growth regulators

383 PIUS, J; GEORGE, L; EAPEN, S; RAO, PS. 1993. **Enhanced plant regeneration in pearl millet (*Pennisetum americanum*) by ethylene inhibitors and cefotaxime**. *Plant Cell, Tissue and Organ Culture*, 32: 1, 91-96.

384 PRASAD, B; SHANTHAMMA, C. 1984. **Changes in the stamens of immature inflorescence of pearl millet cultured in vitro**. *Current Science*, 53: 14, 749-751; 5 ref.

Histological changes in stamens in cultures of immature inflorescences of *Pennisetum americanum* on MS media containing either 2,4-D or NAA are described. On both media, stamen primordia grew together to form a mass of compact tissue. Various types of callus were produced from stamens at a later stage of development.

Diseases

385 PRASAD, B; PRABHU, MS; SHANTHAMMA, C. 1984. **Regeneration of downy mildew resistant**

plants from infected tissues of pearl millet (*Pennisetum americanum*) cultured in vitro. *Current Science*, 53: 15, 816-817; 14 ref.

Plantlets were cultured from diseased immature inflorescence explants taken from HB3 plants infected with *Sclerospora graminicola* and reared to maturity in pots. Seeds from these regenerated plants were grown in downy mildew infested plots in the field and during 3 seasons none of the plants developed symptoms. It is suggested that some of the cells among the original infected callus tissue were resistant and survived to produce whole resistant plants. This technique is believed to provide a novel method of obtaining plants resistant to obligate pathogens.

386 RAMESH, CR; SAFEEULLA, KM. 1985. **Viability and infectivity of *Sclerospora graminicola* in pearl millet seeds by seed callus culture**. *Indian Phytopathology*, 38: 3, 423-426; 9 ref.

A seed callus culture technique was standarized to demonstrate the viability and infectivity of the downy mildew pathogen in *Pennisetum americanum* seeds. The probable percentage of seed transmission of the pathogen was indicated through seed callussing on a nutrient medium. *S. graminicola* produced both oospores and sporangia in the callus tissue. Susceptible seedlings kept in contact with the fungus in flasks developed typical downy mildew symptoms. The importance of seed callus culture in seed transmission studies of seed-borne obligate pathogens is discussed.

387 SHARMA, SB; CHAHAL, SS. 1990. **Application of culture filtrate of *Claviceps fusiformis* for creating stress conditions to pearl millet callus cultures in vitro**. *Plant Disease Research*, 5: 1, 87-89; 12 ref.

When homogenized cell masses from callus cultures of *Pennisetum americanum* were exposed to the culture filtrate before plating onto selective medium, higher mortality rates were obtained than when other techniques were used, thus increasing the chances of selecting cell lines offering resistance to the fungus.

388 SHARMA, SB; CHAHAL, SS. 1990. **Development of regenerants from pearl millet cell lines resistant to culture filtrate of *Claviceps fusiformis***. *Plant Disease Research*, 5: 2, 175-181; 20 ref.

Based on their reaction to ergot, 6 *Pennisetum americanum* lines (ICMPES-28, ICMPES-34-1, PIB-223, PIB-2231, EF-104-2-2 and EF-120-1-1) were selected and their callus cultures from immature inflorescences were initiated and maintained on Murashige & Skoog's medium using 2.5 and 1.5 p.p.m. 2,4-D, respectively, under a 12-h photoperiod at 25 ± 1°C. Large variations occurred in growth and callus formation between the lines. The nodulated callus masses were exposed to 30% (LD 50) culture filtrate of *C. fusiformis* for 72 h. Subsequently, 2 cycles of stress, each of 45 d were repeated on solid selective medium. The callus mass survival varied from 29 to 60% and the cultures that survived were regenerated on half-strength MS + 2 p.p.m. BAP for shoot and half-strength MS + 2 p.p.m. IBA for root formation. The inhibition in root and shoot formation of the regenerants on 30% selective agent was less than with seedlings of the corresponding lines, indicating improvement of resistance in the regenerated plants.

389 SHARMA, SB; CHAHAL, SS. 1989. **Effect of culture filtrate of the ergot pathogen on pearl millet seedlings and callus cultures**. *Indian Journal of Experimental Biology*, 27: 2, 187-188; 10 ref.

Root and shoot length of *Pennisetum americanum* seedlings decreased with increasing concn of culture filtrate of *Claviceps fusiformis*. The culture filtrate was also toxic to callus cultures of ICMPES-34-1, EF-104-2-2 and PIB-2231 lines of pearl millet. There was a levelling effect above 60% concn of culture filtrate. A small proliferating callus mass was observed at 100% callus filtrate concn in ICMPES-34-1.

Other aspects of Pearl millet

390 NDOYE, M; GAHUKAR, R. 1987. **Insect pests of pearl millet in West Africa and their control**. *International Pearl Millet Workshop*. (ICRISAT, Patancheru, India: 1986). p. 183-205; 43 ref.

The insect pests which attack pearl millet in the West African Sahelian zone, which extends through Cape Verde, Senegal, Gambia, Mauritania, Mali, Burkina Faso, Niger and Chad, are reviewed and various control methods are discussed. Major pest species include the noctuids *Acigona ignefusalis* [*Coniesta ignefusalis*], *Sesamia calamistis* and *Raghuva albipunctella* [*Heliocheilus albipunctella*] and the cecidomyiid *Geromyia penniseti*. Cultural control methods include the use of fire, ploughing, partially burning stalks, delaying planting, removal of weeds and the use of nitrogen fertilizers. *C. ignefusalis* may be controlled by one or 2 applications of endosulfan (525-700 mg a.i./ha), chlordimeform (750 g a.i./ha), a mixture of dimethoate and deltamethrin (4 litres/ha) or trichlorfon (1 kg a.i./ha). One application of a dimethoate-deltamethrin mixture, *Bacillus thuringiensis* or diflubenzuron is effective against *H. albipunctella*. Pearl millet varieties which are

resistant to this species have been developed. Important natural enemies of *H. albipunctella* include the parasitoids *Bracon hebetor*, the encyrtid *Litomastix sp.* and the chalcidid *Cardiochiles spp.*; the biology of these species and those attacking *C. ignefusalis* and *G. penniseti* is described.

391 RAO, MVS; NITZSCHE, W. 1984. **Genotypic differences in callus growth and organogenesis of eight pearl millet lines**. *Euphytica*, 33: 3, 923-928; 22 ref.

Variable frequencies of callus initiation from mesocotyl explants were observed among 8 *Pennisetum americanum* varieties using Murashige & Skoog medium supplemented with 2,4-D. Plantlets were regenerated from calluses on medium devoid of auxins. The 8 varieties differed in callus growth rate and frequency of shoot bud production, but all varieties were capable of direct production of at least 1-2 plantlets per callus.

Sorghum

392 BHAT, SS; GOWDA, PSB. 1985. **An efficient method for culturing downy mildew fungi on host callus**. *Transactions of the British Mycological Society*, 84: 1, 161-162; 10 ref.

A method of obtaining conidia of *Peronosclerospora sorghi* and transferring them to host (sorghum) callus to obtain contaminant-free dual culture is described. It was also successfully used to establish *Sclerospora graminicola* on *Pennisetum americanum* callus.

393 GEORGE, L; EAPEN, S. 1988. **Plant regeneration by somatic embryogenesis from immature inflorescence cultures of *Sorghum almum***. *Annals of Botany*, 61: 5, 589-591; 7 ref.

Somatic embryogenesis was obtained from cultured immature inflorescence segments of *S. almum* on Murashige and Skoog (MS) basal medium supplemented with 2,4-D (2 mg/litre) and zeatin (0.1 mg/litre). Somatic embryos germinated into plantlets upon transfer to MS basal medium containing kinetin (0.5 mg/litre) or benzyladenine (1 mg/litre) and developed good root system on medium supplemented with NAA. Addition of benzyladenine to the differentation medium resulted in an increased number of albinos. Plantlets could be established in the field and reared to maturity.

394 MURTY, UR; VISARADA, AA; BHARATHI, M. 1990. **Developing tissue culture system for sorghum, *Sorghum bicolor (L.) Moench*. II. Plant regeneration from embryogenic callus**. *Cereal Research Communications*, 18: 4, 355-358; 8 ref.

Explants from the following sources were studied: (1) scutella from mature seeds; (2) shoot portions of young seedlings; and (3) immature inflorescences. The regeneration media used were BGS, UM, N6, MS with 20 mg IAA/litre and MS with 20 mg IAA and 0.1 mg kinetin/litre. The highest regeneration frequency was obtained on N6 medium from callus induced from immature inflorescences, followed by shoot portions. It was concluded that the most suitable material for long-term biotechnological studies can be obtained from immature inflorescences.

395 NATH, B; OMRAN, AO; HOUSE, LR. 1985. **Identification of a double recessive genotype for 'B' genes controlling presence and absence of pigmented testa in sorghum**. *Cereal Research Communications*, 13: 2/3, 277-279; 4 ref.

The dominant complementary genes B1 and B2, in combination with a spreader gene, S, produce grains with a brown testa and undesirable high tannin content. Thirteen white-grained cytoplasmically male-sterile lines without a pigmented testa were crossed with 2 white-grained testers, IS475 (B1B1 b2b2 SS) and BTx623 (b1b1 B2B2 SS). On the basis of grain colour of F1 plants, 12 of the lines were of genotype b1b1 B2B2 and one (SPL76A) was b1b1 b2b2. SPL76A is considered useful as a seed parent for developing tannin-free hybrids in combination with white-grained restorers of any origin.

Insect pests control

396 ALAGAWADI, AR; GAUR, AC. 1988. **Interaction between *Azospirillum brasilense* and 'phosphate solubilizing bacteria' and their influence on yield and nutrient uptake of sorghum (*Sorghum bicolor L.*)**. *Zentralblatt fur Mikrobiologie*, 143: 8, 637-643; 27 ref., 5 tab.

Interaction between *Azospirillum brasilense* and the 'phosphate solubilizing bacteria' *Pseudomonas striata* and *Bacillus polymyxa*, and their influence on yield, nutrient uptake and acetylene reduction activity of sorghum were studied in a sandy loam alluvial soil under greenhouse conditions. Results showed a significant increase in the yield level of sorghum due to combined inoculation over single inoculation indicating a positive interaction between the 2 groups of bacteria. The yields were further enhanced markedly by the application of 40 kg N as urea and 60 kg P2O5/ha as rock phosphate together with inoculation treatments over fertilizer alone or inoculation without fertilizers. The

possibilities of saving 40 kg N and replacing the entire quantity of superphosphate with rock phosphate plus inoculation of *A. brasilense* and *P. striata* or *B. polymyxa* together are discussed.

397 HARRIS, KM. 1989. **Recent advances in sorghum and pearl millet stem borer research**. *International Workshop on Sorghum Stem Borers*. (ICRISAT, Patancheru, India: 1987: Nov. 17-20). p. 9-16; 45 ref.

Information on stem borers of sorghum and pearl millet published since 1980 is reviewed. Important advances in the knowledge of the biology, ecology and control of the main pest species of the genera Chilo, *Coniesta*, *Diatraea*, *Sesamia* and *Busseola* and other Lepidoptera are summarized. Progress in the assessment of crop losses, the production of resistant varieties, implementation of biological control, and the development of other non-chemical methods of pest management are assessed and requirements for further research and development are identified.

398 MATIBET, M-BETBEDER. 1989. **Biological control of sorghum stem borers.** *International workshop on sorghum stem borers*. (ICRISAT, Patancheru, India: 1987: Nov. 17-20). p. 89-93; 15 ref.

The biological control of the sorghum stem borers *Chilo partellus*, *Busseola fusca*, *Sesamia spp.*, *Eldana saccharina* and *Diatraea saccharalis* with entomophagous insects is reviewed briefly. The use of pathogens is also discussed.

399 MOHAN, S; KARUPPUCHAMY, P. 1987. **A potential predator for sorghum mite, *Oligonychus indicus (Hirst.)***. *Current Science*, 56: 16, 845-846; 4 ref.

The coccinellid *Scymnus gracilis* was observed feeding on large numbers of *Oligonychus indicus* in sorghum fields in Tamil Nadu, India. The population of the predator ranged from 1 to 2 larvae/cm2, with a maximum of 35 larvae and 90 adults and an average of 10 larvae, 15 pupae and 30 adults per leaf. In laboratory studies, larvae of the coccinellid fed voraciously on eggs of *O. indicus* (41.2-71.5 eggs/day), while adults preferred nymphs and adults of the mite (40-50 mites/day).

400 MOTE, UN. 1986. **Effect of carbofuran and *Azospirillum* on shootfly incidence and yield of rabi sorghum cultivars**. *Current Research Reporter, Mahatma Phule Agricultural University*, 2: 1, 118-121; 5 ref.

The compatibility of carbofuran and *Azospirillum* for the control of shootfly [*Atherigona soccata*] on sorghum was tested in Maharashtra, India. The seeds of 3 cultivars were treated with 4% carbofuran, *Azospirillum* (at 250 g/10 kg seed) or carbofuran plus *Azospirillum*. There were no differences in percentage germination, either between treatments or between cultivars. There was a greater reduction in *Atherigona soccata* incidence and a higher grain yield following treatment with carbofuran alone and in combination with *Azospirillum* than in no treatment or treatment with *Azospirillum* only. Grain yield was increased by 12.42, 22.07 and 26.44% after treatment with *Azospirillum*, carbofuran, and carbofuran and *Azospirillum*, respectively. Significantly fewer deadhearts were recorded in the cultivars M.35-1 and SPV-86 compared to CSH-8R. It is concluded that *Azospirillum* can reduce the incidence of *Atherigona soccata* and increase yield, but that it is more effective in combination with carbofuran.

401 RAO, KJ; THONTADARYA, TS; SUHAS, Y. 1986. **Investigations on parasitoids and predators of sorghum pests**. *Sorghum Newsletter*, No. 29: 59-60.

Surveys of natural enemies of sorghum pests were carried out in Karnataka, India. The main parasitoids and predators of the cecidomyiid *Contarinia sorghicola*, the pyralids *Chilo partellus* and *Marasmia trapezalis*, the noctuids *Mythimna separata* and *Heliothis armigera* [*Helicoverpa armigera*] and *Rhopalosiphum maidis* are listed. Notes on the biology of several parasitoid species and the damage caused by pests are included.

402 REDDY, KVS. 1989. **Sorghum stem borers in Eastern Africa**. *International Workshop on Sorghum Stem Borers*. (ICRISAT, Patancheru, India: 1987: Nov. 17-20). p. 33-44; 46 ref.

The stem borer species infesting sorghum in East Africa are listed and the distribution, biology, ecology and yield losses of the most important species *Chilo partellus*, *C. orichalcociliellus*, *Eldana saccharina*, *Busseola fusca*, *Sesamia calamistis* and *S. cretica* are discussed. Control methods include cultural control, plant resistance, biological control, chemical control and the use of pheromone and light traps.

403 REYES, R. 1989. **Sorghum stem borers in Central and South America.** *International workshop on sorghum stem borers (1987:17-20 November:Patancheru, India)*. (ICRISAT, Patancheru, India: 1987: Nov. 17-20). p. 49-58; 46 ref.

The importance, distribution, seasonal abundance, food plants and life cycle of the pyralids *Diatraea lineolata* and *D. saccharalis*, pests of sorghum in Central and South America, are reviewed. Current control strategies, including cultural, biological and chemical meth-

ods, are outlined. The natural enemies of each species, including parasitoids, predators, pathogens and hyperparasitoids, are listed.

404 SUKHANI, TR. 1986. **Insect pest management in sorghum**. *Plant Protection Bulletin, India*, 38: 1-4, 57-61; 40 ref.

Methods for the integrated control of sorghum pests in India including the muscid *Atherigona soccata*, the pyralid *Chilo partellus*, the noctuid *Sesamia inferens*, the cecidomyiid *Contarinia sorghicola* and the mirid *Calocoris angustatus* are discussed. Early sowing is an effective means of reducing *A. soccata* and *C. sorghicola* damage and *C. partellus* and *S. inferens* may be controlled by proper disposal of the previous season's stubble. Resistant varieties appear to be a promising method of controlling sorghum pests. Preliminary data has been collected on the parasitoids and predators of the latter 4 species, but further studies are needed to develop techniques for their mass rearing and release. Various chemicals may be used to control these pests.

405 THONTADARYA, TS; RAO, KJ. 1987. **Biology of *Orius maxidentex* Ghauri (*Hemiptera*: *Anthocoridae*), a predator of the sorghum earhead midge, *Contarinia sorghicola (Coquillet)***. *Mysore Journal of Agricultural Sciences*, 21: 1, 27-31; 2 ref.

The biology of *Orius maxidentex* was studied in the laboratory, using insects collected from the field in Karnataka, India, and the cecidomyiid *Contarinia sorghicola* and sorghum flower thrips [*Thysanoptera*] as prey. Incubation took 4 days in both hosts. There were 4 nymphal instars and the total development time was 11-20 and 10-22 days in *C. sorghicola* and the thrips, respectively. Females laid a maximum of 86 and 128 eggs and lived for 7-18 and 5-29 days with these prey. An average of 15.80 and 24.40 *C. sorghicola* and 35.10 and 78.61 thrips were consumed by males and females, respectively. No difference was observed in sex ratio between anthocorids reared on the 2 prey species. In the field, *O. maxidentex* fed on nymphs and adults of *C. sorghicola* and thrips on sorghum, white flies [*Aleyrodidae*] on chilli [*Capsicum*] and thrips on cotton. These are new prey records for this predator.

Rice

406 ANURATHA, CS; GNANAMANICKAM, SS. 1987. ***Pseudomonas fluorescens* suppresses development of bacterial blight (BB) symptoms**. *International Rice Research Newsletter*, 12: 1, 17.

Bacterization of rice seedlings by coating seeds and spraying seedlings 20 DAS with a rice isolate of *P. fluorescens* biotype III caused a substantial reduction (40-60%) in bacterial blight (*Xanthomonas campestris pv. oryzae*).

407 BALACHANDRAN, SM; HOAN, NT; SARMA, NP; SIDDIQ, EA. 1994. **Production and evaluation of doubled haploids from rice hybrids**. *Second Asia-Pacific Conference on Agricultural Bioctechnology*. (Madras: 1994: 6-10 Mar). p. 55. p. 55.

408 BALASUBRAMANIAN, M. 1986. **Host resistance in integrated pest management in rice**. *Plant Protection Bulletin, India*, 38: 1-4, 31-33; 6 ref.

The use of resistant rice varieties in integrated pest management in India is outlined. Resistant varieties have been used successfully for the control of the cecidomyiid *Orseolia oryzae*, the delphacid *Nilaparvata lugens* and the cicadellid *Nephotettix virescens*. Varietal resistance has also been used in combination with insecticide treatments and natural enemies. Host plant resistance has 3 main components: non-preference, antibiosis and tolerance. The techniques used to make the most of the available resistance genes are summarized.

409 CHAUDHURI, MM; GHOSH, B. 1984. **Purification and characterization of diamine oxidase from rice embryos**. *Phytochemistry*, 23: 2, 241-243; 30 ref.

Diamine oxidase of rice seedlings was purified 1800-fold to homogeneity. The mol. wt. of the enzyme as determined by Sephadex G-100 gel filtration was 12.3 X 104 and the enzyme contained 2 identical subunits each with a mol. wt. of 6.12 X 104. The opt. temp. and pH for the enzyme were 30° and 7.5, resp., and the enzyme followed typical Michaelis kinetics with a Km of 10-5 M. Each enzyme molecule contained 4 molecules of FAD.

410 CHAUDHURI, MM; GHOSH, B. 1982. **Purification and partial characterization of arginine decarboxylase from rice embryos (*Oryza sativa L.*)**. *Agricultural and Biological Chemistry*, 46: 3, 739-743; 14 ref.

Arginine decarboxylase after purification from rice seedlings was separated into fractions A and B with mol. wt. of 88 000 and 174 000, resp. Fraction B was more active than A. The active fraction had an opt. pH of 8 and temp. of 45°C, a Km value of 0.28 mM, and consisted of 16 amino acids of which proline was prominent. Inhibition of the enzyme was greatest with spermine and hydroxylamine. Kinetin, GA3 and IAA stimulated, but ABA inhibited activity of the enzyme.

411 DHAR, MS; DABAK, MM; GUPTA, VS; RANJEKAR, PK. 1988. **Organisation and properties of repeated DNA sequences in rice genome**. *Plant Science, Irish Republic*, 55: 1, 43-52; 29 ref.

Reassociation of high molecular weight rice DNA revealed the occurrence of long stretches of repeated DNA which are not interrupted by single copy DNA even at a fragment length as high as 20 kbp. Most of these repeated sequences were unusually G+C rich and they showed significant variations in thermal stability. Homology studies indicated that some short repeats may have evolved from the long repeats, while short repeats in the highly repetitive DNA fraction may have a different origin. Restriction enzyme analysis showed the occurrence of AvaI and EcoRV repeat families.

412 DUTTA, SK; CHAUDHURI, RK; VERMA, MADHU; VERMA, MUKESH. 1987. **Molecular cloning of ribosomal RNA genes of *Oryza sativa* and its use in the identification of subspecies of rice**. *Nucleus, India*, 30: 3, 83-93; 13 ref.

Nuclear DNA isolated from subsp. japonica cv. S201 was digested with PstI and cloned into plasmid pBR322. A clone, pDCMV-S201-13, was characterized in detail and its physical map was constructed. This showed coding sequences for 5.8S, 17S and 26S rRNAs as well as internal transcribed spacers and flanking sequences at the 5' and 3' ends of rDNA sequences. When the clone was radiolabelled by nick translation and used as a probe, it sucessfully differentiated cultivars of subspp. japonica and indica based on hybridization studies using genomic blots of known reference cutivars.

413 FALASCHI, A. 1990. **The International Centre for Genetic Engineering and Biotechnology of UNIDO**. *Trends in Biotechnology*, 8: 11, 314-317; 7 ref.

The origins of the ICGEB are briefly outlined by its director. The 43 member countries (chiefly developing countries) are listed. The Trieste (Italy) component focuses on industrial biotechnology while the New Delhi (India) component deals more with agricultural and health applications. The latter includes projects led by J. Bennett aimed at glyphosate resistant plants, insect resistant rice and RFLP analysis of the rice genome, and by K. Tewari to develop plant transformation vectors based on chloroplast DNA. Details are given of training courses, a Ph.D. programme, collaborative research, scientific services and funding.

414 GUNATHILAGARAJ, K; BABU, PCS; GOPALAN, M. 1987. **Mycosis of *Nilaparvata lugens (Stal.)* from India**. *Curr. Science*, 56: 21, 1124-1125; 10 ref.

The fungus *Absidia corymbifera* was observed infecting dead individuals of the delphacid rice pest *Nilaparvata lugens* in an insectary culture in India. This fungus was found to be pathogenic to *N. lugens* and *Sogatella furcifera* at 10-6 spores/ml 7 days after treatment in the laboratory. However, it was not pathogenic to the acridids *Hieroglyphus banian* and *Oxya nitidula*, the lymantriid *Psalis pennatula*, the coreid *Leptocorisa oratorius* or the pyralid *Cnaphalocrocis medinalis* at the same inoculum level. Natural infection of *N. lugens* in Tamil Nadu was a maximum of 60% in January and a minimum of 4% in April-July. This is thought to be the first report of *A. corymbifera* on *N. lugens*. *A. corymbifera* may be mass-produced using moist sterile sorghum grains, but its use as a microbial insecticide is subject to safety tests, as it is reported to be associated with human bronchomyces.

415 GUPTA, HS. 1987. **A rapid staining technique for staging of microspores in rice (*Oryza sativa L.*) and rice bean (*Vigna umbellata*)**. *Current Science*, 56: 20, 1072-1073; 12 ref.

The technique described uses acetic acid iron alum-haemotoxylin to stain the nucleus deep grey to black against the colourless cytoplasm, allowing the stage of microspore development to be determined clearly when selecting anthers for culture.

416 HEINRICHS, EA; KATANYUKUL, W; KARIM, ANMR; MISRA, BC. 1986. **Management of insect pests in rainfed lowland rice**. *Progress in Rainfed Lowland Rice*. 349-358; 12 ref.

The status of the most important insect pests of rice in Bangladesh, India, the Philippines and Thailand are described, and various methods for their control, including chemical, biological and cultural control, integrated pest management and the use of resistant varieties, are discussed. Methods for improving control tactics of these pests are suggested.

417 HIKIM, IS. 1988. **Seasonal parasitism by egg parasites of the yellow rice borer, *Scirpophaga incertulas* (Lepidoptera: Pyralidae)**. *Entomophaga*, 33: 1, 115-124; 18 ref.

An investigation was conducted from 1979 to 1981 in West Bengal, India, to determine the most important native egg parasitoids of the rice pest *Scirpophaga incertulas*, and to study their searching and survival capacity throughout the year. The results revealed that egg parasitoids are important in reducing the population of *S. incertulas* in an uninterrupted rice cultivation practice. The parasitoid activity showed periodic fluctua-

tions coinciding with moth emergence. The scelionids *Telenomus spp.* were the most common and dominant parasitoids in the early summer crop and became highly adaptive under diverse crop growing situations. Among the 3 species of Telenomus found, *T. rowani* was the most abundant in the summer and winter seasons. The eulophid *Tetrastichus schoenobii* was second in importance in regulating the population of *S. incertulas*, and its attack was heaviest on the later broods in rice crops cultivated during the winter. *Trichogramma japonicum* was very sporadic and had a particular preference for the dry period. It usually occurred in association with other parasitoids, especially *Telenomus spp.*, in the later part of the year. Parasitism of egg masses by 2 or more species of parasitoids was also common at this time during the peak period of parasitoid activity.

418 JAIN, BK. 1988. **SEM and light microscopic studies during embryo development in *Oryza sativa L.*** *Biovigyanam*, 14: 1, 44-53; 26 ref.

Globular embryo cells had intense, uniform staining for RNA, total proteins, sulphur amino acid proteins and insoluble polysaccharides. Scanning electron microscopy (SEM) and histological studies revealed that during elongation the embryo has 2 unequal sectors, the germinal which develops into the plumule radicle axis, and the abgerminal (cotylar) which gives rise to the cotyledon organs. The coleoptile does not originate from the plumule and is not a leaf. The coleorhiza is cotylar and envelops the radicle. No homogeneity was demonstrated between the radicle and the epiblast.

419 JHALA, RC; PATEL, ZP; SHAH, AH. 1987. **Occurrence of *Altica cyanea (Weber)*, a possible biocontrol agent for weeds in rice fields**. *Gujarat Agricultural University Research Journal*, 13: 1, 64; 3 ref.

The chrysomelid *Altica cyanea* was observed feeding on weeds, especially *Spermacoce hispida*, *Ludwigia parviflora* and *Ammannia baccifera*, in rice fields in southern Gujarat, India. During a survey carried out in 1984, an average of 54.4, 19 and 17.4 adults/plant was found feeding on *S. hispida*, *L. parviflora* and *A. baccifera*, respectively. The weeds were completely defoliated, and no damage to rice plants was observed. The chrysomelid is regarded as a possible biological control agent against weeds in rice fields in southern Gujarat.

420 KARIM, NH; ZAPATA, FJ. 1990. **One-step rice plantlet development through anther culture**. *Indian Journal of Plant Physiology*, 33: 2, 119-124.

421 KENMORE, PE. 1986. **Some aspects of integrated pest management in rice**. *Plant Protection Bulletin, India*, 38: 1-4, 11-13.

Some important aspects of integrated pest management in the Indian rice crop are outlined. Integrated pest management depends on identifying the most appropriate combination of control methods for a particular situation. Methods developed by farmers have often proved to be effective and should be taken into account. Natural enemies effectively suppress many insect pest populations but insecticide sprays have a harmful affect on natural enemies and there is a need to inform farmers of their presence. The importance of training farmers to implement integrated pest management is stressed.

422 KISHOR, PBK; REDDY, GM. 1984. **In vitro selection of PEG and NaCl resistance in rice**. *Mutation Breeding Newsletter*, No. 24: 6.

Calli from one-week-old seedling roots and mature embryos of the variety Bala were initiated on Linsmaier & Skoog (LS) medium supplemented with 2 mg 2,4-D/litre, 2% sucrose and/or sorbitol and/or mannitol. On sucrose plus sorbitol and sucrose plus mannitol media, callus tissues were light yellow in colour and looked healthy. Root and embryo calli proliferating on 2% sucrose with addition of 3% sorbitol and/or 3% mannitol produced shoots over a period of 700 and 600 days, respectively. Of the different sucrose concentrations (0, 1, 2, 3, 6 and 10%) tested, 2% was optimal for shoot formation. Plants regenerated from callus cultures showed variation in total number of tillers per plant, number of productive tillers per plant, length of panicle and number of fertile and sterile seed per panicle. Embryo-derived callus of Tellahamsa was grown in LS liquid medium containing 2% sucrose for about 10 days. Cells growing in small clumps were plated on LS agar medium supplemented with 2.5 and 5% polyethylene glycol (PEG). Cells resistant to 5% PEG were grown on the medium for 95 days and plantlets were regenerated with 14-15% frequency. Cells resistant to 2.5% PEG (250 days old) were also regenerated and grown to maturity. Embryo-derived calli of Jaya and Tellahamsa were grown on LS medium containing 1% or 3% sodium chloride. Cells resistant to 3% sodium chloride were grown for 88 days and plantlets were regenerated wth 2-3% frequency.

423 KISHOR, PBK; REDDY, GM. 1985. **Organogenesis and plantlet formation from callus cultures of scented and non-scented cultivars of rice**. *Sabrao Journal*, 17: 2, 181-185; 8 ref.

Calluses derived from immature inflorescences, seedling roots or mature embryos of up to 8 indica cultivars showed various degrees of growth and shoot formation when cultured on Linsmaier & Skoog medium with growth regulators that varied among cultivars and explant sources. Embryo-derived callus of Tellahamsa and its induced dwarf mutant 6-1 showed the greatest frequency of shoot formation (60-70%) and hence, as root formation differed little, the greatest regenerative ability. A 2% sucrose conc. proved optimal for shoot formation. Regenerated plants were grown to maturity and showed a wide range of variability for total and productive tiller number, panicle length and fertility.

424 KRISHNAIAH, K. 1986. **Status of integrated pest management in rice**. *Plant Protection Bulletin, India*, 38: 1-4, 5-10; 12 ref.

Information on the status of different components of integrated pest management in the Indian rice crop at farm level is summarized. Pest surveillance and the development of appropriate economic thresholds are important for the timing of insecticide applications. Pest surveillance also provides information on the relative abundance of pests and their natural enemies and the performance of resistant or tolerant varieties. Pesticides continue to be the dominant component of control programmes and spraying and dusting are the main methods used for insecticide application. The use of resistant varieties, natural enemies and various cultural methods are also important. Integrated pest management has resulted in increased yields in all areas where it has been implemented.

425 KRISHNAIAH, PV; RAO, PS; RAO, NHP; RAO, PS; NARASIMHAM, V. 1987. **Control of rice hispa**. *Indian Farming*, 37: 7, 37, 39

The distribution, biology, ecology and control (chemical and cultural) of the chrysomelid rice pest *Dicladispa armigera* in India and the nature of damage caused by this pest are described. *Microbracon sp. [Bracon sp.*] and the eulophid *Tetrastichus sp.* parasitize larvae and pupae of *D. armigera*, but there is no specific biological control programme against this pest. At present no varieties are known to be resistant to *D. armigera*, but some cultures are less preferred than others.

426 KULASOORIYA, SA; SENEVIRATNE, PRG; DE SILVA, WSAG; ABEYSEKERA, SW; WIJESUNDARA, C; DE SILVA, AP. 1988. **Isotopic studies on N2-fixation in *Azolla* and the availability of its nitrogen to rice**. *Symbiosis*, 6: 1-2, 151-166; 7 ref.

The use of *Azolla* as a nitrogen fertilizer depends primarily upon its ability to fix nitrogen efficiently and on the availability of this nitrogen to an associated crop. In this study, 15N-labelled material was used to evaluate N2 fixation by *Azolla* in the field and to assess N-uptake from *Azolla* by rice with respect to the time of incorporation and in relation to its quality. *Azolla* derived 50-60% of its nitrogen through fixation and this was equivalent to 11-14 kg N ha-1 during a 14-day growth period. N-uptake was better when *Azolla* was incorporated at tillering than at transplanting and the recovery of nitrogen by rice from *Azolla* was more efficient than from urea, except when the fibre:nitrogen content of *Azolla* was high.

427 MAJUMDAR, N; BRAHMACHARI, GK. 1987. **Prime avian predators controlling insect and rodent pests of paddy in India; management of their econiches - its feasibility and some suggestions**. *Tigerpaper*, 14: 2, 16-22; 26 ref.

The role of birds as predators of insect and rodent pests of rice in India is reviewed. Twenty-five insectivorous species and 12 species which are predators of rodents in rice are listed. It is suggested that the natural habitat of avian predators should be conserved and convenient perches should be provided.

428 MIAH, MAA. 1990. **Performance of some callus derived doubled haploid lines in rice (*Oryza sativa L.*)**. *Bangladesh Journal of Botany*, 19: 1, 79-81.

429 MIAH, MAA. 1994. **Present status of rice biotechnology at BRRI**. *Workshop on Present Status and Future Direction of Biotechnological Research in Bangladesh*. (BARC, Dhaka: 1994: June 25).

430 MIAH, MAA. 1985. **Studies on the Association between yield and yield components in anther derived doubled haploid rice (*Oryza sativa L.*)**. *Bangladesh Journal of Botany*, 14: 2, 147-155.

431 MIAH, SA; SHAHJABAN, AKM; KARIM, NH; MIAH, MAA. 1985. **Varietal screening of rice anthers for culturability**. *Proceedings of the national Symposium on Agricultural research*. (BARC, Dhaka: 1985: Dec. 22-23).

432 MUTHUSWAMI, M; GUNATHILAGARAJ, K. 1989. **Effect of rice gall midge (GM) resistance on parasitic behavior of *Platygaster oryzae* Cameron**. *International Rice Research Newsletter*, 14: 4, 19.

The influence of GM [*Orseolia oryzae*] resistance in rice on the parasitic activity of the GM parasite *P. oryzae*

was studied in 1987. GM incidence was recorded in 20 varieties with different levels of GM resistance. Parasitization was recorded as the percentage of parasitized galls. The correlation between incidence of GM and that of its parasite was negative (r = -0.63). RP1579-4-6-1 had 1.8% GM incidence and 100% parasitization, while TNAU831520 had 81.5% GM incidence and only 9.0% parasitization. In general, adult *P. oryzae* emergence from galls was low in resistant varieties.

433 NADAF, SK; GOUD, JV; PARAMESWARAPPA, R. 1992. **Genetic studies in rice (*Oryza sativa L.*). Inheritance of flowering**. *Journal of Genetics and Breeding*, 46: 3, 283-286.

In a cross between D 6-2-2 (early) and HY-256 Purple (late), inheritance of flowering was studied at Agricultural Research Station, Mugad, Dharwad district, during Kharif 1987-89. The F1 resembled the late parent indicating earliness to be recessive. F2 population segregated into a ratio of 15 early: 49 late indicating that three interacting genes were operating, two of which (Ef1 and Ef2) are duplicate genes and one (I-Ef) is an inhibitory gene.

434 NADAF, SK; GOUD, JV; PARAMESWARAPPA, R. 1992. **Genetic studies in rice (*Oryza sativa L.*). A case of pleiotropy in four panicle traits**. *Journal of Genetics and Breeding*, 46: 2, 119-124.

The present investigation was conducted to understand the inheritance of four panicle traits, in a cross between two upland cultivars, D 6-2-2 (green) and HY-256 Purple (purple) at Agricultural Research Station, Dharwad during Kharif 1987-89. Awning and red awns segregated for presence vs absence into the ratios of 3:1021 and 3:4093 respectively, with an involvement of a basic gene for their expression along with four and five inhibitory duplicate genes respectively. Three complementary genes and one inhibitory gene were found to control blackening of lemma/palea at flowering to give ratio of 27 presence: 229 absence. A tetragenic ratio of 219:37 for difficult vs easy threshing types was observed indicating the involvement of one independent dominant gene and three complementary genes. Existence of one to four pleiotropic common genes which act either similarly or differentially for the development of the panicle traits was recognised based on the results of F2 data concerning each character, combined segregation ratios and breeding behaviour of F3 families.

435 NAIR, NK; NAIR, VG. 1982. **Mutational analysis of embryo differentiation in rice**. *Agricultural Research Journal of Kerala*, 20: 2, 1-7; 6 ref.

Seeds of cv. Rohini were treated with 2 doses each of ethyl methanesulphonate and gamma rays. The M1 plants were studied for the ontogenic relationship of the tillers, and M2 seedlings, which were raised as M1 ear progenies, were scored for chlorophyll and other mutations. Analysis of cluster sharing frequencies (the frequency with which 2 M1 ears segregated for identical mutations) revealed that the first to the fifth tiller primordia had already differentiated from the shoot primordium in the rice embryo, so that there were at least 6 mutually exclusive mutant sectors which did not have any mutations in common. It is concluded that all the primary ears up to the fifth, besides the main ear, should be collected from M1 plants for raising the M2 generation in order to recover all the mutations induced.

436 NAIR, SA; QANNIE, PT; NAIR, P GOPINATHAN. 1992. **Variability in auxin response among collections of *Oryza* malampuzhensis Krishn. Et. Chandr. during in vitro raising of selfed progenies**. *Ind. J. of Genetics and Plant Breeding*, 52: 3, 334-336.

437 NANDA, DR; MISHRA, BB; MISRA, BN. 1989. **Toxicity degradation of waste soil from a chlor-alkali factory by *Azolla pinnata Lam.*** *Plant and Soil*, 116: 1, 103-106; 14 ref., 3 tab.

Cultures of *Azolla pinnata* grown in various mixtures of soil plus industrial waste from a chlor-alkali factory for 30 to 60 days, resulted in the addition of significant amounts of nitrogen and organic carbon to the growing medium. A considerable decrease in the alkaline pH of the waste/soil was also recorded. On transplantation of rice seedlings into the waste/soil mixtures, after 60 days of *Azolla* culture it was observed that the rice survived and continued to grow in mixtures containing 30% waste whereas, in control conditions, seedlings failed to survive in above 15% waste/soil combinations.

438 NILUFER H KARIM; SHAHJAHAN, AKM; NAHAR, MAKSUDA A; MIAH, SA; HAQUE, MZ. 1991. **Improved media for callus induction of Indica cultivars of Rice (*Oryza sativa L.*)**. *Plant Tissue Culture*, 1: 1 43-50.

439 NILUFER H KARIM; NABORS, MW. 1994. **Salt Tolerance of callus induced rice**. *Bangladesh Journal of Botany*, 23: 1, 1-6.

440 PALANICHAMY, K; SIDDIQ, EA. 1982. **Relative role of A- and C-genome species of genus *Oryza* in the evolution of cultivated rices through isoenzyme variation**. *Oryza*, 19: 3/4, 178-184; 23 ref.

Esterase and peroxidase isoenzymes were analysed in 52 strains of ten A-genome species and two strains of *O. officinalis*. Similarities between and within the three subspecies of *O. perennis* were high. There were similarities between *O. sativa* and *O. perennis subsp. balunga* and between *O. glaberrima* and *O. perennis subsp. barthii*. All the above species were highly divergent from *O. officinalis*. It is concluded that *O. officinalis* was not directly involved in the evolution of the cultivated species.

441 PANDEY, MP; SESHU, DV; AKBAR, M. 1992. **Genetic variation and association of embryo size to rice seed and seedling vigour**. *Indian Journal of Genetics and Plant Breeding*, 52: 3, 310-320.

442 PATHINAYAKE, BD; JOHNSON, DL. 1989. **Effect of culture media and temperature treatments on callus formation in anther culture of different rice (*Oryza sativa L.*) genotypes**. *Tropical Agriculturist*, 145, 31-43.

443 PATNAIK, NC; MOHANTY, B; PARIDA, AK. 1987. **Nisaga simplex caterpillar on rice in western Orissa**. *International Rice Research Newsletter*, 12: 4, 44.

Observations were carried out on the biology of the eupterotid Nisaga simplex, which regularly causes damage in upland and medium rice fields in western Orissa, India. Adults emerged in June at the onset of the monsoon and oviposited on weedy growth in scrubby jungles and adjoining rice fields. The incubation period lasted 7-9 days. In the laboratory, 8 larval instars were completed in 68-76 days. Pupation took place in the soil. Larvae fed voraciously on the rib lamina, leaving only the midrib. In the field, the pest pupated in loose lateritic soil, often as deep as 30 cm, in October and overwintered until the following June. Weedy fields attracted larger populations than weed-free ones. The larvae also attacked maize, sorghum, finger millet, sugarcane and 15 weed species including *Cynodon dactylon*, *Echinochloa sp.*, *Leersia hexandra* and *Panicum repens*.

444 PAWAR, AD. 1986. **Role of natural enemies in the integrated pest management of rice**. *Plant Protection Bulletin, India*, 38: 1-4, 15-26.

The main ways of using natural enemies in integrated pest management to control rice pests are outlined. Natural enemies may be conserved by using insecticides or formulations which are least harmful and by timing applications to reduce the impact on beneficial arthropods. Natural enemy populations may be enhanced by increasing the diversity of plant species in the vicinity of the crop, changing cultural practices to ensure continuous availability of hosts and by providing alternative food sources. Natural enemy populations may be augmented by mass releases but this appears to be less feasible than the conservation and enhancement of naturally occurring populations. Attempts to use exotic parasitoids have generally proved unsuccessful and most species have failed to become established in their release areas. The use of pathogens for insect pest control is outlined and the potential natural enemies of rice insect pests in India are listed.

445 RAHMAN, SG; AMIN, MN; ZUBERI, MI. 1990. **Selection for salt tolerance among some rice cultivars of Bangladesh**. *International conference High Salinity Tolerant Plants in Arid Regions*. U.A.E., University al-Ain, Abu Dhabi:

446 RAINA, SK; HADI, S. 1987. **A simple device for mass extraction of rice anthers**. *International Rice Research Newsletter*, 12: 3, 23-24.

The device consists of a 125 ml polypropylene (or similar substance) bottle into the screw cap of which a 3.5 cm steel tube is fitted. From the bottom to about 3/4 up the bottle, horizontal slits 1.5 mm wide, 3 cm long and 4 cm apart are made in 4 vertical rows, so that the slits of one row correspond to the gaps of the adjacent rows. Extraction is carried out under sterile conditions. The sterilized florets, cut at the distal and basal ends, are collected in the bottle (containing a teflon-coated magnet), which is placed in a beaker containing 300 ml of liquid medium. The beaker is placed on a magnetic stirrer for 1 min, the steel tube in the bottle being held to keep the device in position. During stirring, the anthers pass through the slits in the bottle into the medium leaving the glumes behind. Anther yields of >80% have been obtained in <50% of the time needed for conventional isolation.

447 RAJAGOPAL, ASM; MANDI, S SEN. 1992. **Studies on acid and alkaline phosphatases in aged rice embryos**. *Proceedings of the International Seed Testing Association*, 20: 2, 215-222.

448 RAJAK, RL. 1986. **Integrated pest management (IPM) in rice crop prospects and retrospects**. *Plant Protection Bulletin, India*, 38: 1-4, 1-4.

The implementation of integrated pest management in the Indian rice crop is reviewed. Major insect pest species cause considerable losses in yield. Integrated

pest management makes use of a variety of control methods in order to reduce the use of pesticides. A number of surveys are used to monitor pest populations. An educational programme in integrated pest management has been set up for farmers and extension agencies and there are demonstrations in 13 states. Major components of the integrated pest management programme include varietal resistance, monitoring, augmentation of natural enemies and appropriate cultural methods. The benefits and constraints of integrated pest management are listed.

449 RAJENDRAN, TS; NAIR, VG. 1983. **Estimation of the number of initial cells in panicle primordia of the rice embryo**. *Agricultural Research Journal of Kerala*, 21: 2, 1-6; 19 ref.

Cv. Rohini was treated with ethyl methanesulphonate and gamma rays. Ears were collected separately from the apical, primary and secondary tillers of the M1 and the M2 were raised as M1 ear progenies. The M3 were raised as M2 plant progenies, and data are tabulated on the segregation ratios for mutants in the M2 and M3. The size of the mutated sector of the M1 panicle, and the number of initial cells, was estimated from the M2 and M3 segregation ratios. The number of initial cells in the apical ear ranged from 2 to 12, but the other ears originated from only 1 to 3 cells. It is concluded that a larger progeny must be grown to recover a mutation induced in the primordium of the apical ear compared to that of the other ears. There was a deficit of recessive mutants in the M3.

450 RAO, PS; CHADHA, MS. 1986. **Protoplast culture of some economically important plants. Studies on plant regeneration.** *Nuclear techniques and in vitro culture for plant improvement. Proceedings of a symposium organized jointly by the International Atomic Energy Agency and the Food and Agriculture Organization of the*. (Vienna, IAEA: 1985: 19-23 August), p. 493-496, 7 ref.

Mesophyll protoplasts of *Arachis hypogaes* were isolated but the callus derived from them could not be induced to regenerate plantlets.

451 RAUT, RS; DHUMALE, DB; LOKHANDE, VE. 1989. **Induction of callus and regeneration of plants in rice bean (*Vigna umbellata Thumb*)**. *Annals of Plant Physiology*, 3: 1, 25-28; 5 ref.

Calluses were produced from stem segments on MS medium containing 1 mg 2,4- D litre and plants were regenerated on MS medium containing 2 mg benzyladenine and 0.4 mg kinetin/litre.

452 REDDY, VD; REDDY, GM. 1992. **Genetic instability in rice**. *Journal of Genetics and Breeding*, 46: 3, 247-252.

Genetic instability in rice has been observed in a rice mutant, induced after Nitroso-methyl urea + hydrazine treatment. Red mottling on bronze coloured kernels and developmental variants like notched grain, male steriles, dwarf plant type, altered grain shape, altered flag leaf length and area, were observed in M3, M4, M5 and M6 generations suggesting instability. Variable degree of expression of kernel mottling and new kernel phenotypes, red and bronze, were observed in the M5 generation raised from M4 mottled plant. The mottling pattern of M5 seeds had no influence on the M6 plant progenies. Also irrespective of the phenotypes, red, bronze and bronze mottled in the M5 generation, bronze mottled progenies were observed predominantly in the M6, whereas white M5 seeds gave mostly white seeded M6 progeny. The cross of instable bronze mottled line with that of white line gave bronze and bronze mottled F1s, and in F2 generation, segregation for coloured VS colourless (white) varied from progeny to progeny (4.46:1 - 7.41 :1) and did not conform to normal genetic ratios. A transposable element system is suspected in this mutant possibly due to the mutational activation of a silent element present in the rice genome.

453 ROYCHOUDHURY, PK; GHOSE, TK; GHOSH, P; CHOTANI, GK. 1986. **Vapor liquid equilibrium behaviour of aqueous ethanol solution during vacuum coupled simultaneous saccharification and fermentation**. *Biotechnology and Bioeng.*, 28:7, 972-976; 10 ref.

Data was obtained on the ethanol-water vapour-liquid equilibrium in the presence of cellulase, enzymes, nutrients, yeast, and rice straw in a vacuum-coupled simultaneous saccharification and fermentation process. There was a substantial increase in ethanol concn in the vapour phase at reduced pressures. The max. relative volatility of ethanol in the presence of the added components was approx. twice that of the pure ethanol-water system. The equation correlating the activity coefficient and ethanol concn in the liquid phase adequately represented the equilibrium behaviour.

454 SARKER, RH; SAMAD, MA; SERAJ, ZI; HOQUE, MI; ISLAM, AS. 1993. **Pollen tube growth in crosses between Porteresia coarctata and *Oryza sativa***. *Euphytica*, 69: 1-2, 129-134.

455 SARKER, SC. 1991. **Biosynthesis of storage proteins in developing endosperm of rice (*Oryza sativa L. Tribe indica cv. Nazirshail)* [of Bangladesh].**

Proceedings of the workshop on Bangladesh Agricultural University Research Progress. Bangladesh Agricultural Univ., Mymensingh (Bangladesh) p. 156-162.

An indigenous variety of rice, Nazirshail was grown hydroponically during the transplant aman season of 1989. Single stem was maintained. Total protein contents of the endosperms were analysed from 2 days after flowering up to maturity of the grain. Synthesis of storage protein was found to be started from 4 DAF in the developing endosperms. Sodium-dodycil-sulfate-polyacrylamide-gel-electrophoresis revealed that glutelin and prolamin started to be synthesized at around 4 DAF and 9 DAF, respectively. Glutelin was initially synthesized as a large molecular weight precursor polypeptide which subsequently cleaved into two subunit structures of mature glutelin. Maximum content of this precursor protein was found to be at around 10 DAF. Cleavage into glutelin subunits continued, maintaining the steady state concentration of the precursor up to maturity of the grain. The molecular weights of the precursor and the two subunits of glutelin were determined to be 57 kDa, 37-39 kDa and 21-22 kDa, respectively.

456 SECOND, G. 1984. **Different rates of genome divergence presumed between two species groups in the genus *Oryza***. *Nucleus*, 27: 1/2, 44-48; 6 ref.

Multivariate analysis of data from 24 isozyme loci in 181 strains belonging to the *O. sativa* species group (wild forms of *O. sativa* and very close relatives; genome AA) and from 17 isozyme loci in 25 strains belonging to the *O. latifolia* species group (genomes BB, CC, EE, BBCC, CCDD and probably DD) revealed that (1) genome differentiation has been more rapid in the *O. latifolia* group than in the *O. sativa* group and (2) there is incipient genome divergence within the AA genome. It is suggested that the more rapid genome divergence in the *O. latifolia* group species may be due to their higher DNA contents.

457 SHAH, CK; JAIN, BK. 1983. **The fabric of the rice embryo**. *Biovigyanam*, 9: 2, 109-116; 18 ref.

Morpho-histochemical studies during rice embryo development are described. Changes in extinction value (e. value) and content/cell of RNA, SH proteins, nucleic acids and insoluble polysaccharides showed higher intensity at the globular stage and declined as the embryo approached maturity.

458 SHAHJAHAN, AKM; NILUFER, MAN; KARIM, H; MIAH, NM; MIAH, SA. 1992. **Evaluation of dihaploid rice derived through anther culture**. *Plant Tissue Culture*, 2: 1, 1-6.

Forty-seven anther calli-derived dihaploid rice plants obtained from indica and japonica cultivars and F1 and F2 plants of crosses between indica/indica and indica/japonica genotypes at H1, H2 generations and eight selected dihaploids at H3 generation were evaluated in the field during T. Aman and Boro seasons. There was a wide variation among dihaploids for plant height, tiller number/hill, panicle length, spikelet number/panicle, sterility, maturity and yield. Compared to the mother plant/sister line or the check cultivars most were poor in yield. However, three anther culture (AC) lines, BR 1083-226-4-AC-lb and BR2799-10-4-6-3-AC-2 for T. Aman and IR9729-AC-la for Boro appeared better than the rest. It is suggested that further improvement of these three lines through crossing with desirable genotypes and anther culture of the F1 hybrids is possible.

459 SHAHJAHAN, AKM; NILUFER H KARIM; MIAH, SA. 1984. **Response of Indica, Japonica and Japonica Indica F1 hybrid rice anthers to callus induction in liquid and semisolid media**. *Proceedings of the 9th Bangladesh Association for the advancement of Science Conference*. (1984: March 2-7). Bangladesh Association for the Advancement of Science, Dhaka, Bangladesh.

460 SHARMA, DK. 1994. **RELP analysis of DNA extracted from gall midge resistant rice varieties of Central India**. *Second Asia-pacific conference on Agricultureal Biotechnology at madras*. (1994: March 6-10). Directorate of Research Services, Indira Gandhi Krishi Vishwa Vidyalaya, Raipur- 492 012 (M.P.).

461 SHARMA, RK; KOTHARI, RM. 1993. **An innovative approach to improve productivity of rice.** *Internat. Rice Res. Newslett.* 18: 19-20.

462 SHEIKH, MI; KHAN, BA; KHAN, NA. 1988. **Effect of spawn age and different substrates (compost) on yield of Chinese mushroom**. *Recent advances in biotechnology and applied biology: Proceedings of Eighth International Conference on Global Impacts of Applied Microbiology and International Conference on Applied Biology and Biotechnology*. (Hong Kong: 1988: Aug 1-5). Hong Kong: Chinese University Press, p. 565-569; 7 ref.

The growth of *Volvariella volvacea*e or Chinese mushroom, an edible mushroom of tropical and sub-tropical areas, on various substrates was investigated. The effect of spawn age and substrate on the yield was studied. A cotton waste compost inoculated with old spawn gave the highest yield, followed by paddy straw.

463 SINGH, J; SINHA, MM. 1987. **The brown backed planthopper *Nilaparvata lugens (Stal)* (*Delphacidae, Homoptera*) - a serious pest of rice**. *Pesticides*, 21: 3, 29-32, 42.

The host range, biology, ecology and control (cultural, chemical and biological) of *Nilaparvata lugens* in India, and the nature of damage caused by the delphacid to rice are discussed.

464 SITANSU-PAN; CHITRESHWAR-SEN; PAN, S; SEN, C. 1986. **Relative toxin(s) production by parental and fungicide adapted isolates of *Macrophomina phaseolina* in culture**. *Indian Journal of Plant Pathology*, 4: 1, 57-62; 10 ref.

A study of in vitro production of toxins by these isolates confirmed their nonspecific nature. Toxin production was not linked with virulence. Fungicide adaptation altered the amount of toxin produced as indicated by the inhibition of rice radicle growth and symptom expression on the soyabean cv. Braga. In vitro, more potent toxin was produced by *Allisan* [dicloran]-adapted isolates than by those tolerant of quintozene or carboxin. Carbendazim-adapted isolates produced the least potent toxin.

465 SOENARJO, E. 1986. **Alang-alang gall midge potential as an alternate host for parasites**. *International Rice Research Newsletter*, 11: 5, 22-23

A study was carried out in West Java, Indonesia, to determine whether *Orseolia javanica*, which attacks Alang-alang (*Imperata cylindrica*), a naturally occurring weed on the dykes of lowland rice, could be an alternative host of parasites of the rice pest *O. oryzae*. The life cycle of *O. javanica* is longer (5-7 weeks) than that of *O. oryzae* (4-5 weeks); the life cycle of the parasite *Platygaster oryzae* was longer on *O. javanica* than on *O. oryzae*. Based on biology and behaviour, *Platygaster sp.* attacking *O. javanica* is now considered to belong to the complex of *P. oryzae* attacking *O. oryzae*. It attacks larvae of *O. oryzae*, and pupae of *O. javanica* because the parasites deposits eggs only when the silvershoots caused by the latter emerge. Three other parasites were also reared from *O. javanica*.

466 SON, P; BOSAH, RC; DEKA, PC. 1993. **Differential accumulation of shetelin in developing grains of Pamkaj and Mahsuri**. *Oryza*, 30: 120-123.

Two rice varieties, Pamkaj and Mahsuri were compared for their differential levels of souble protein total fee amino acid and accumulation of glutelin and different stage of grain development. the grain crude protein content in Mahsuri was found to be 10.59 g 100 g-1 dry matter as against 11.24 g-100 g-1 in case of Pankaj was at a higher level as compared to Mahsuri at different states of grain development, however, the levels of free amino acid was higher in Mahsuri. Thus, for the synthesis of protein, the levels of total free amino acid was not limiting in the developing grain of Mahsuri. Pankaj contained higher amount of glutelin it all stages of grain development as compared to Mahsuri. However, in mature grain percentage wise Mahsuri contained 71.98% glutelin as against 66.07% in Pankaj.

467 SUR, K; BASU, RN; MANDAL, K. 1985. **Effect of irradiation on the deteriorative senescence of embryo and endosperm of rice (*Oryza sativa L.*) seed**. *Indian Journal of Plant Physiology*, 28: 4, 303-309; 14 ref.

Using an embryo-endosperm reciprocal transplantation technique, it was shown that gamma-irradiated rice endosperm adversely affected the growth of non-irradiated embryos transplanted on them. The poor growth of the non-irradiated embryo-irradiated endosperm transplant could be due to a decrease in gibberellin-induced alpha-amylase production in the aleurone cells of the endosperm. However, an exogenous supply of GA partly overcame the adverse effect of irradiation implying damage to other biomolecules and bioorganelles participating in the reactions leading to germination and early seedling growth.

468 THOMAS, G; PADAYATTY, JD. 1983. **Organization and bidirectional transcription of H2A, H2B and H4 histone genes in rice embryos**. *Nature*, 306: 5938, 82-84; 23 ref.

A genomic clone in the plasmid vector pBR322 carrying H2A, H2B and H4 histone genes on a DNA fragment of 6.64 kb (isolated from 48 h germinated embryo DNA of IR20) was studied. A restriction map of the insert showed that the H2A and H2B genes were located at one end of the insert and the H4 gene at the other with a 3.1 kb spacer in between. Transcription was bidirectional with the H2A and H2B genes being encoded by one strand and the H4 gene by another.

469 TIWARI, VN; LEHRI, LK; PATHAK, AN. 1989. **Effect of inoculating crops with phosphomicrobes**. *Experimental Agriculture*, 25: 1, 47-50; 13 ref., 4 tab.

Seed inoculation with *Bacillus polymyxa* markedly increased the yields of rice and chickpea (*Cicer arietinum*) crops, while *Pseudomonas striata* caused a greater impact on crop production when used with rock phosphate or superphosphate in a wheat crop. The effect of

the phospho-microbe inoculants was greater in phosphorus-deficient soils.

470 VENUGOPAL, MS. 1985. **Problems and priorities in the management of rice gall midge**. *Cecidologia Internationale*, 6: 1/3, 97-99.

The cecidomyiid *Orseolia oryzae* is a serious pest of rice in India and the severity of damage it causes has increased in the last decade following the spread of high-yielding semi-dwarf rice varieties, which are highly susceptible to it, and accompanying technologies such as heavy nitrogen application and closer spacing continuous cropping. Chemical control is limited due to the cost, weather limitations and because the pest is an internal feeder. The complexity of the problem is complicated by the existence of biotypes in different regions. Control of *O. oryzae* will centre on an integrated approach involving cultural, varietal, chemical and biological methods. Studies on the development of resistant varieties of rice should take into consideration factors such as better adaptability, multiple resistance, high yield potential and improvement of grain quality in developing fairly long durable resistant varieties. There is also scope for intensifying studies on the mechanism of resistance. Biological control has not been attempted. The parasites *Platygaster oryzae* and *Platygaster spp.* occur in fairly large numbers in the field, but parasitism occurs late in the crop season. The development of techniques for mass rearing these parasites and field release methods need to be explored. Other aspects which need to be investigated include the use of pheromone and light traps.

471 VIJAYAKUMAR, KR; VILASINI, AP; MAMMEN, G; VAMADEVAN, VK. 1988. **A case study of the spread and harmful effects of *Salvinia molesta* in the rice fields of the command area of Kuttiayadi Irrigation Project and approaches to minimize the weed problem**. *Irrigation and Power*, 45: 2, 177-191; 3 ref.

A study has been carried out on the spread and harmful effects of *Salvinia molesta*, an aquatic weed that has spread extensively through the water bodies of Kerala State, India. Survey results are given detailing the spread of the weed through the paddy fields of the Kuttiayadi Irrigation Project. The type of damage caused by the weed is described, the management approaches which can be adopted to control the weed (such as lime or weedkiller application flood control and biological control) are evaluated and estimates are made of the economic ramifications.

472 WILLIAMS, MNV; PANDE, N; NAIR, S; MOHAN, M; BENNETT, J. 1991. **Restriction fragment length polymorphism analysis of polymerase chain reaction products amplified from mapped loci of rice (*Oryza sativa L.*) genomic DNA**. *Theoretical and Applied Genetics*, 82: 4, 489-498; 29 ref.

Thirty mapped indica rice genomic (RG) clones were partially sequenced from each end. From such sequence data, pairs of oligonucleotides were synthesized to act as primers for polymerase chain reaction (PCR) amplification of the corresponding loci in crude total DNA preparations. The PCR products from DNA of indica varieties were of the sizes expected from the sizes of the corresponding RG clones. However, size polymorphisms were seen between PCR products from indica and japonica varieties, and among wild *Oryza* species. Restriction fragment length polymorphism (RFLP) was observed between PCR products of indica varieties simply by electrophoretic analysis of restricted products, without the need for Southern hybridization or radiolabelling. The RFLPs noted between varieties ARC6650 and Phalguna were inherited in recombinant inbred lines derived from a cross between them. The RFLPs were detectable in PCR products amplified from DNA extracted by a simple procedure from single seedlings or leaves, and revealed genetic heterogeneity in cultivated lines.

Propagation

473 NILUFER H KARIM; ZAPATA, FJ. 1992. **Effect of Abscisic acid on the physico-chemical changes and plant regeneration in anther derived calli of rice**. *Plant Tissue Culture Conference*. (BINA, Mymensingh: 1992: Dec 15).

Hybridization

474 MIAH, NM. 1990. **Breeding research rice in Bangladesh.** *Proceedings of the First National Symposium on Plant Breeding in Bangladesh*. Plant Breeding and Genetics Society of Bangladesh, Dhaka, p. 1-31.

Rice improvement work was started in Dhaka in 1911. Since then a total of 52 varieties were released through pure line selection for the four seasons: 15 for Aus, 22 for T. aman, 9 for B. aman and 6 for boro. Introduction of varieties from other countries was started in 1934 and by 1960 from 13 different countries 136 varieties were introduced from among these, 2 varieties were released, blue stick from America and Nizersail from Nigeria.

475 NIJAGUNA, G; MAHADEVAPPA, M. 1983. **Heterosis in intervarietal hybrids of rice**. *Oryza*, 20: 2/3, 159-161; 10 ref.

When crosses of MTU3, Bilekagga and Y4 with male-sterile IR36 were studied, an assortment of positive and negative heterotic effects were found for days to heading, tiller number, harvest index, grain yield, plant weight, spikelet weight, grains/plant, 1000-grain weight, straw yield and spikelet sterility.

476 PAT, WARAWIT PANICH; ANGOON, TEERAPORN BOOZAYA; TRACHOO, PAIBOON. 1986. **Crossing Basmati with IR36.** *Proc. of the 24th National Conference*. Kasetsart Univ., Bangkok, p. 413-418.

Among the milled rice sold in the world market, the variety consistently getting the highest price is Basmati, a native rice variety of Punjab, India. Consequently many rice exporters had introduced Basmati into Thailand, and encouraged farmers to grow it for export. Results of extensive tests on several Rice Research Centers and Rice Experiment Stations for many seasons, Basmati can grow in Thailand, but the yield is rather low. Although it tillers well, there are few grains per panicle and plenty of empty spikelets. Yield per rai averages 300-400 kg, which was rather low in spite of good management. Therefore, if the paddy price per ton is not more than 2-3 times the price of high yielding varieties, farmers will not recover the high cost of production. The immediate attention for a breeding program is to breed Basmati quality rice with high yield by correcting the low fertility. The most significant characteristic which should be maintained is the cooking quality. The progenies selected should have equal cooking quality to Basmati.. Hybridization between Basmati and IR36 was started in 1983. The pedigree method was used for selection. At this moment, it is in the fifth generation, with 78 selected families. These families resulted from selection in grain appearance, milling and cooking quality tests.

Tissue and anther culture

477 ARUNA, M; REDDY, GM. 1988. **Genotypic differences in callus initiation and plant regeneration from anthers of indica rice**. *Current Science*, 57: 18, 1014-1017; 10 ref.

Anthers of 11 indica varieties were cultured on 6 different media. Chaleff's R2 medium was suitable for callus initiation in all the varieties tested. Varietal response depended on the medium used. Frequency of callus induction on R2 was fairly high in PTB33 (12.5%), B(D5) X B(C) (9%) and Crossa (8%) compared with Rasi (4.5%), TH(C) (2%), Masuri X Bala (1.5%), TN1 X Carreon (1%), TCA2 X YVSD (1%) and Pokkali (0.5%). The varieties Assam 5, Gopalbhog, Pankaj, Radhunipagal, Annapurna and Chittimuthyalu showed no response. Initiation of callus took place within 20 days in PTB33 and Crossa. Pretreatment of anthers by low and high temperatures had a stimulatory effect on initiation. Regeneration of green plants occurred at a high frequency in Rasi (47.5%), PTB33 (35%) and TC(C) (10%). Somaclonal variation was observed in regenerated plants along with pollen sterility. Of 7 PTB33 regenerants, only 2 were haploid.

478 GEORGE, L; JOSHUA, DC; EAPEN, S. 1989. **Cytogenetic studies on regenerated plants of indica rice cultivars**. *Sabrao Journal*, 21: 2, 103-110; 22 ref.

Callus cultures initiated from mature caryopses of 3 varieties differentiated through a process of somatic embryogenesis and organogenesis. The R1 regenerated plants were generally shorter than the control, with thinner stems and different degrees of pollen and seed sterility. Meiotic analysis showed that 71% of regenerates had one or more types of cytological aberration, the most frequent being asynchrony in division, cytomixis and PMCs of different sizes. Aneuploidy and structural changes such as chromosome translocations were also present. Of the 85 R1 progeny plants from which the R2 was derived in one of the varieties, 52 (61%) showed segregation for morphological traits.

479 GUPTA, HS; PATTANAYAK, A; BHUYAN, RN; PANDEY, DK. 1989. **Cytokinin-mediated induction of embryogenic calli and plant regeneration in indica rice (*Oryza sativa*)**. *Indian Journal of Agricultural Sciences*, 59: 8, 526-528; 7 ref.

Seeds of Khonorullo, Pusa 33, RCPL1-2C and RCPL1-1C were cultured on Linsmaier and Skoog (LS) medium supplemented with 25 mg tryptophan, 1 mg kinetin and 2.5 mg 2,4-D/litre. Calluses were seen on the surface of the scutellum after 10-12 days. With further proliferation 2 morphologically distinct types of callus were observed; (1) embryogenic callus composed mostly of isodiametric cells which were yellowish and compact with organized globular structures, and (2) non-embryogenic callus composed mostly of tubular cells which were white, unorganized and soft. Frequency of callus formation depended on the genotype. All 3 supplements were necessary in the LS medium to achieve successful induction and proliferation. On transfer to N6 medium without growth regulators embryogenic calluses further proliferated and formed embryoids which developed

coleoptile, scutellum and roots. These structures produced plantlets with roots and shoots.

480 GUPTA, HS; BORTHAKUR, DN. 1987. **Improved rate of callus induction from rice anther culture following microscopic staging of microspores in iron alum-haematoxylin**. *Theoretical and Applied Genetics*, 74: 1, 95-99; 22 ref.

Two local indica varieties, Khonorullo and Namyi, and 2 advanced indica lines were tested for their response to anther culture. High frequencies of callusing were obtained from microspores which were stained in iron alum-haematoxylin prior to culture on various media. The frequency of callusing was highest in PK1-1-3 (45.5%, on G5 medium), followed by PK12-22 (32.4%, on E24 medium), Khonorullo (31.6%, on minimal medium) and Namyi (9.5%, on G5 medium). Cold shock (10°C for 11 days) increased the frequency of callusing in Khonorullo by 200% over the untreated control.

481 GURUNATHAN, GM; RANGASAMY, SRS. 1983. **Anther culture in rice**. *International Rice Research Newsletter*, 8: 4, 10-11.

F1 and F2 crosses of ASD8/Vaigai, ASD8/Amaravathi, ASD8/Bagavathi and ASD8/Zhinjan responded to anther culture by producing calluses after 35-42 days of incubation in darkness at 24-26°C. The calluses were induced by growth on potato extract medium and N6 medium supplemented with 2 mg 2,4-D/l. The ASD8/-Bagavathi cross produced the best anther response of 9.51%, and all crosses responded best on N6 medium.

482 KARIM, NH; SHAHJAHAN, AKM; MIAH, MAA; HAQUE, MJ; MIAH, SA. 1986. **Anther culture of rice**. *Newsletter, International Plant Biotechnology Network*, No. 6: 8.

Of 14 media tested, M10 was considered most suitable for the culture of both japonica and indica cultivars. Anthers required 8-10 days in the dark at 8-10°C to produce maximum callus. Culture in the dark at 25°C for 3 weeks also enhanced callus production. A high proportion of plants regenerated from callus were albino but green dihaploid [doubled haploid?] plants were also recovered.

483 KARIM, NH; NAHAR, MA; SHAHJAHAN, AKM; KANTER, DG; HAQUE, MZ; MIAH, SA. 1987. **Regeneration of anther-derived callus**. *International Rice Research Newsletter*, 12: 2, 26.

Gamborg's B5 medium with 4 modifications was tested on anther-derived callus from 9 indica rice varieties and 5 F2 crosses of deep water rice for regeneration and production of green and multiple shoots. The results obtained indicated varietal differences in regeneration ability and shoot production. No single medium appeared suited to the complete range of genotypes tested. The modifications to the medium used are given.

484 KARIM, NH; SHAHJAHAN, AKM; MIAH, MAA; MIAH, SA. 1985. **Response of rice anthers to callus induction and plant regeneration**. *International Rice Research Newsletter*, 10: 3, 21-22.

Cold-shocked anthers of 40 boro varieties, breeding lines and F2 plants were cultured on N6 (for japonica forms), and modified H5 and SK8 (for indica and indica X japonica) media at the early to mid-uninucleate stage of microspore development. Of the 18 lines that produced callus, 2 were japonica, one was indica X japonica and 15 were indica (names provided). Anther response ranged from 0.4 to 37.0%. Zhinghua 5 and Habiganj Boro VIII showed the best response. Two weeks after induction, calluses were transferred to MS [Murashige & Skoog] regeneration medium supplemented with 0.5 mg IAA/litre and 1.0 mg kinetin/litre. Percentage root development was 30.8-100%. Albinism was more frequent than green-plantlet regeneration (23.1 vs. 7.7%). Zhinghua 5 produced the greatest percentage of green plantlets (25%) and showed the lowest ratio of percentage albino to percentage green plantlets produced (37 : 25).

485 KARIM, NILUFER H; ZAPATA, FJ. 1993. **Physico-chemical changes and plant regeneration in anther- derived calli of rice by abscisic acid treatment**. *Plant Tissue Culture*, 3: 1, 11-15.

Abscisic acid at concentrations of 10, 20 and 30 mg/l were used to observe changes in moisture accumulation, total protein, proline and sugar content and plant regeneration on the anther-derived calli of rice var. Taipei 309. Increasing ABA concentration resulted in decreased moisture accumulation. The total protein content did not show any marked variation. No proline accumulated due to increasing ABA levels. The highest accumulation of total sugar was observed at 20 mg ABA/l with concurrent regeneration of green plants.

486 KISHOR, PBK. 1989. **Activities of phenylalanine- and tyrosine-ammonia lyases and aminotransferases during organogenesis in callus cultures of rice**. *Plant and Cell Physiology*, 30: 1, 25-29; 33 ref.

Activities of phenylalanine ammonia-lyase, tyrosine ammonia-lyase, phenylalanine aminotransferase and tyrosine aminotransferase (involved in the shikimic acid

pathway) were examined during initiation of roots and shoots in callus cultivars of rice cv. Bala. Enhancement of the activities of tyrosine-ammonia lyase and tyrosine aminotransferase but not of phenylalanine- ammonia lyase and phenylalanine aminotransferase was observed in organ-forming cultures, as compared with activities of these enzymes in non-organ-forming cultures. The role of these enzymes in such organogenetic processes is discussed.

487 KISHOR, PBK. 1989. **Aromatic amino acid metabolism during organogensis in rice callus cultures**. *Physiologia Plantarum*, 75: 3, 395-398; 22 ref.

Activity of key enzymes involved in aromatic amino acid metabolism was examined in rice cv. Bala callus cultures during root and shoot initiation. Increased activities of the enzymes quinate:NAD+ oxidoreductase, shikimate kinase, chorismate mutase, anthranilate synthase and tryptophan synthetase were noticed in organ-forming callus compared with proliferating rice callus, especially prior to visible organogenesis.

488 KISHOR, PBK; REDDY, GM. 1987. **Callus initiation and plantlet regeneration from different explants and genotypes of *Oryza sativa L.*** *Indian Journal of Plant Physiology*, 30: 1, 66-70; 14 ref.

Specific min. 2,4-D concn in the medium were necessary for callus initiation from seedling roots, mature embryos (0.5 mg/litre) and immature inflorescences (1 mg) of rice. Plantlet regeneration occurred at a higher frequency in embryo-derived callus (65-70%) than in inflorescence (45-50%) and root callus tissues (30%). Embryo callus of cv. Tellahamsa continued to regenerate shoots for up to 295 days, while the calluses of other cv. lost ability to regenerate shoots much earlier. Regenerated plants grown to maturity showed phenotypic variation.

489 KISHOR, PBK. 1988. **Effect of salt stress on callus cultures of *Oryza sativa L.*** *Journal of Experimental Botany*, 39: 199, 235-240; 20 ref.

Callus cultures of rice adapted to grow under increasing NaCl stress accumulated considerable amounts of free proline compared with unadapted cells. Salt-adapted cells grown for 10 passages (25 days each) on NaCl-free medium accumulated proline on re-exposure to salt, as did cells which were grown continuously on NaCl. On replacing NaCl (100 mol/m3) with 100 mol KCl/m3, FW and DW as well as free proline content of salt-adapted callus declined compared with that attained on 100 mol NaCl/m3. However, equimolar concn of NaCl and KCl (when added together) increased growth and free proline accumulation in salt-adapted callus. Omission of Ca2+ from the growth medium inhibited the growth of salt-adapted cells in the presence of NaCl, while it had little effect on the growth of non-adapted cells in the presence of NaCl. ABA increased FW and DW of the non-adapted callus in the presence of 200 mol NaCl/m3 but not in the absence of NaCl. ABA failed to evoke the same response in salt-adapted cells in the presence of the salt. Tissues exhibited good growth under inhibitory levels of NaCl (500 mol/m3) only when glycine betaine, choline and proline were added to the medium; they showed no growth in the presence of sarcosine, glycine or dimethylglycine.

490 KISHOR, PBK. 1987. **Energy and osmotic requirement for high frequency regeneration of rice plants from long-term cultures**. *Plant Science, Irish Republic*, 48: 3, 189-194; 23 ref.

In order to apply tissue culture techniques in breeding, callus derived from mature embryos was cultured on media containing different sucrose concentrations. The callus showed optimum growth at 300 mOsmol. The minimum sucrose concentration required for root differentiation was 0.5%, whereas for shoot differentiation it was 1.0%. Tissues grown on medium containing a lower sucrose concentration produced shoots at a high frequency only if the medium was supplemented with sorbitol or mannitol to raise the osmolarity. Callus growing on sucrose as sole carbon source lost its shoot-forming ability by 100 days in culture, whereas tissues proliferating on media containing sorbitol or mannitol besides sucrose differentiated shoots over a period of 1500 days.

491 KISHOR, PBK; REDDY, GM. 1986. **Improvement of rice for tolerance to salt and drought through tissue culture**. *Oryza*, 23: 2, 102-108; 19 ref.

In tests of 13 varieties, embryo-derived callus tissues of Tellahamsa and its induced dwarf 6-1 showed the greatest growth and shoot differentiation (60-70%). There were differences in height, number of tillers per plant, number of productive tillers per plant, panicle length and numbers of fertile and sterile grains per panicle between seed-grown plants of Tellahamsa, plants regenerated from immature panicle callus and plants from embryo callus. Plants of Tellahamsa were regenerated from callus adapted to 1% NaCl or 2.5% polyethylene glycol (for water stress) at frequencies of 20-25% and 35-38%, respectively.

492 KISHOR, PBK; ARUNA, M; REDDY, GM. 1989. **Plant regeneration from haploid callus of**

indica rice. *Proceedings of the Indian National Science Academy, Part B: Biological Sciences*, 55: 3, 193-202; 46 ref.

Calluses were induced from anthers of 6 indica cultivars, one indica X japonica hybrid and 4 F1 hybrids using several media, of which Chaleff's R2 medium produced the best results. Induction frequencies varied from 0.5-13% (PTB33). Intervarietal differences were noted in plant regeneration but Pokkali, TCA2 X YVSD, TNI X Carreon and Mahsuri X Bala failed to produce any green plantlets. Wide phenotypic variability was noted in several regenerated plants. Optimal concentration of sorbitol in regeneration medium was 30 g/litre in the presence of 2% sucrose and replacement with mannitol had similar effects. Incorporation of sugars, amino acids and starches did not enhance the growth or shoot-forming ability of calluses.

493 KISHOR, PBK; REDDY, GM. 1986. **Regeneration of plants from long-term cultures of *Oryza sativa L.* *Plant Cell Reports***, 5: 5, 391-393; 15 ref.

Root and embryo derived callus tissues of rice grown on sucrose alone as C source lost their ability to organize shoots by 75 and 100 days in culture, resp. Along with 2% sucrose, either 3% sorbitol or 3% mannitol was necessary in the growth medium for the callus to regenerate whole plants over a period of 1400 days without any decline in the shoot-forming ability. Incorporation of sorbitol or mannitol in the callus proliferating medium provided long-term totipotent rice cultures with a high frequency (50-60%) of shoot differentiation.

494 KISHOR, PBK; REDDY, GM. 1986. **Regeneration of rice plants from long-term root and embryo-derived callus cultures**. *Current Science*, 55: 14, 664-665; 8 ref.

Callus was initiated from primary root explants and mature embryos of cv. Bala on modified Linsmaier & Skoog (LS) medium. Calluses initiated on medium with sucrose as sole carbon source regenerated shoots at a frequency of 20-23% on LS medium containing 1 mg IAA plus 4 mg kinetin/litre. Whereas root callus lost its ability to initiate shoots by 75 days and embryo callus by 100 days in culture, the rhizogenic potential of both callus types was retained beyond 100 days. Root amd embryo calluses of Bala initiated on 2% sucrose plus 3% sorbitol or mannitol and then transferred to the same regenerating medium as before produced shoots over a period of 600 days. Shoots were produced in 15-20 days with 49-61% frequency.

495 KISHOR, PBK; REDDY, GM. 1985. **Resistance of rice callus tissues to sodium chloride, and polyethylene glycol**. *Current Science*, 54: 21, 1129-1131; 10 ref.

Callus cultures of Jaya and Tellahamsa were initiated from mature embryos on medium with or without polyethylene glycol (PEG) and NaCl. Those grown with NaCl showed reduced growth compared with tissues maintained without NaCl. Plantlet regeneration on fresh medium from callus from the 1% NaCl treatment was 15-16% for Jaya after 58 days and 20-25% for Tellahamsa after 80 days. Suspension cultures of Tellahamsa were also initiated from all the calli and small clumps of cells were plated on media containing 2.5 and 5% PEG. These cells were light yellow and healthy, as opposed to control cells never exposed to PEG, and showed better growth, in terms of fresh and dry weight gain. The 2.5% PEG treatment gave the better plantlet regeneration.

496 KISHOR, PBK; REDDY, G. 1986. **Retention and revival of regenerating ability by osmotic adjustment in long-term cultures of four varieties of rice**. *Journal of Plant Physiology*, 126: 1, 49-54; 16 ref.

Root and embryo-derived callus tissues of 4 varieties exhibited better growth on Linsmaier & Skoog medium containing 2% sucrose plus 3% sorbitol or 3% mannitol than tissues grown on 2% sucrose. Callus tissues proliferating on 2% sucrose alone lost their ability to regenerate shoots after 75-300 days in culture, depending on the variety. These tissues regained shoot forming ability after growing on 2% sucrose plus 3% sorbitol or 2% sucrose plus 3% mannitol for a minimum period of 50 days. When sorbitol and mannitol were withdrawn from the growth media, callus tissues lost their ability to organize shoots again within 45-50 days in the same regenerating medium. Tissues proliferating at an osmolarity of 299-304 milliosmol/litre produced plantlets in the regenerating medium over a period of 1400 days with a frequency response of 50-60%

497 KISHOR, PBK. 1989. **Salt stress in cultured rice cells: effects of proline and abscisic acid**. *Plant, Cell and Environment*, 12: 6, 629-633; 19 ref.

Growth of salt-adapted callus derived from rice cv. Kallahamsa embryos was little affected by 1 or 10 mol proline/m3 in media containing 100 or 200 mol NaCl/-m3 but proline accumulated in the presence of 100 mol NaCl + 10 mol proline/m3. Growth and proline content of salt-unadapted callus increased with 100 mol NaCl + 1 or 10 mol proline/m3. On replacing NaCl with KCl (100 and 200 mol/m3), growth of salt-adapted and

unadapted callus was inhibited, although 10 mol proline/m3 had an ameliorating effect. ABA suppressed adapted and unadapted callus growth in the absence of salt stress. ABA inhibited the growth of callus adapted to and grown in 100 and 200 mol/m3 of NaCl and on replacement of NaCl by equimolar concn of KCl. Growth of 100 mol NaCl/m3-adapted cells was inhibited when they were transferred to a medium containing 200 mol NaCl but was stimulated in the presence of ABA. ABA increased the growth of unadapted cells when subjected to different salts and accelerated the adaptation of cells exposed to salt but not to water deficits imposed by nonionic solutes.

498 KUMARI, DS; SARMA, NP; RAO, GJN. 1988. **Micropropagation of cytosterile rice stocks**. *International Rice Research Newsletter*, 13: 2, 5-6.

Dehusked and surface-sterilized grains of the cytoplasmically male- sterile stock V20A were germinated on Murashige & Skoog (MS) medium with 50 g sucrose/litre. Six-day-old excised seedling shoots were transferred to fresh MS medium containing benzyladenine to induce the formation of multiple axillary shoots. Clumps of shoots were separated and subcultured on fresh medium. Rooting occurred on MS medium containing NAA.

499 KUMARI, DS; SARMA, NP; RAO, GJN. 1987. **Tissue culture propagation of cytosterile stocks**. *International Rice Research Newsletter*, 12: 2, 24-25.

The cytoplasmically male-sterile rice lines V20A, Madhu A, IR48483A and IR46830A, all with WA cytoplasm, were mass produced as follows. Callus was initiated from dehusked, sterilized grains by culturing on N6 medium supplemented with 2 mg 2,4-D/litre; each embryo yielded 400-500 mg of callus within 3-4 weeks. The calluses were transferred to MS [Murashige & Skoog] regeneration medium containing NAA, kinetin and benzyladenine (0.75, 0.25 and 0.75 mg/litre, respectively). Within 3 weeks, 200-250 plantlets were obtained. With a second cultural passage, the callus from a single grain gave rise to 2000-3000 plantlets. Using this method, the multiplication rate of stock as plantlets was 1 : 200, and hardened seedlings of a size suitable for transplanting were obtained in 11-12 weeks. Observations limited to plantlets obtained directly from embryo calluses revealed no somaclonal variation.

500 MAHESWARAN, M; RANGASAMY, SRS. 1992. **Changes in peroxidase activity during shoot formation in *Oryza sativa L.*** *Journal of Genetics and Breeding*, 46: 1, 15-19; 19 ref.

Callus cultures were established from mature seeds of cv. IR50 on MS basal medium supplemented with various combinations of 2,4-D and kinetin. The presence of 2 mg 2,4-D and 0.5 mg kinetin/litre in the induction medium proved effective for callus induction and regeneration. Induction of callus was noticed from the hypocotyls of seedlings within 10-14 days after inoculation. Regions of meristematic activity showed apolarity when the callus was grown in 2,4-D containing medium and these meristemoids showed directional divisional activity when the callus was transferred to kinetin-containing medium. Histological studies of regenerating calluses revealed multiple shoot formation. Calluses at different growth stages were used for analysis of peroxidase isoenzymes as markers of morphogenesis. Calluses at 3 growth stages were subject to zone electrophoresis for peroxidase isoenzymes. The peroxidase isozymes were resolved into 3 groups, P1, P2 and P3. Synthesis of P3, a group of fast migrating bands was noticed during the process of differentiation. Growth hormones also influenced isoenzymes pattern.

501 MAHESWARAN, M; RANGASAMY, SR. 1989. **Effect of 2,4-D and kinetin on callus induction and plant regeneration from somatic cell cultures of rice**. *Oryza*, 26: 3, 302-305; 13 ref.

Hypocotyl callus from IR50, IR1552 and Co43 induced on medium containing 2 mg 2,4-D and 0.5 mg kinetin/litre showed higher regeneration capacity than other treatment combinations. Level of regeneration varied with genotype and concentration of growth regulators.

502 MAHESWARAN, M; RANGASAMY, SRS. 1988. **Esterase isozyme as a marker in in vitro studies of rice**. *International Rice Research Newsletter*, 13: 6, 11-12.

Esterase banding patterns were studied in 21-day-old callus and regenerating callus of 3 *Oryza sativa* varieties, *O. spontanea* and *O. glaberrima*. Esterase patterns were similar at the callus induction stage, but genotypic differences were apparent at the regenerative stage. Genotypic differences in regenerative ability were also noted and it is suggested that esterase isoenzymes could be used as a marker for this trait.

503 MAHESWARAN, M; RANGASAMY, SR. 1988. **Genotypic relationship in *Oryza* species under in vitro conditions: use of esterase isozymes as markers during morphogenesis**. *Genetica Agraria*, 42: 4, 365-370; 7 ref.

Electrophoretic patterns of isoenzymes are useful as markers in determining the morphogenetic potential of

callus. Esterases were used in in vitro studies involving *Oryza spontanea*, *O. glaberrima* and the *O. sativa* cultivars Co43, IR50 and IR1552. *Electrophoresis* during callus induction revealed similarities in esterase banding among all the genotypes except *O. spontanea*. Although the species showed similarities and dissimilarities unique esterase bands occurred in each which could be used for species identification. The occurrence of slow migrating bands during the regeneration stage could be used as a marker of morphogenesis.

504 MAHESWARAN, M; RANGASAMY, SRS. 1989. **Influence of genotypes and culture media on callus induction and plant regeneration in *Oryza* species**. *Journal of Genetics and Breeding*, 43: 3, 165-169; 14 ref.

Callus induction and in vitro green plant regeneration were studied using 5 genotypes viz., *O. spontanea*, *O. glaberrima* and *O. sativa* cultivars Co43, IR50 and IR1552. The culture requirements differed with cultivars within the species and between the species of the same genus. The *O. sativa* cultivar IR50 gave the best callus induction response and the highest percentage of green plants regenerated (40.9). Production of albino plantlets was observed in cultivar Co43. MS medium containing 2,4-D (2.0 mg/l) combined with 0.5 mg kinetin/litre was effective for callus induction.

505 MAHESWARAN, M; RANGASAMY, SRS. 1989. **Somatic embryogenesis in rice cultivar IR50**. *International Rice Research Newsletter*, 14: 2, 6-7.

Somatic embryos were produced by culturing calli derived from seedling hypocotyls after dehulled seeds were cultured on MS medium with 2,4-D and kinetin. They had 2 distinct poles and were attached to the callus piece through their broader surface. Embryoids of different shapes were also seen during the early stages of embryogenesis.

506 MANIMAKALAI, GURUNATHAN; RANGASAMY, SR. 1988. **Anther culture and somatic embryogenesis in rice improvement**. *Oryza*, 25:1, 16-22; 13 ref.

Anthers of 2 japonica and 5 indica varieties and 5 indica X indica crosses were cultured on modified N6 medium, with subsequent regeneration on modified MS medium. The 2 japonica varieties responded best to callus induction. The anthers of the F1s of IR50 X ARC6650 (derived from pest and disease resistant parents) were cultured and doubled haploids were obtained via embryoids; 12 stable homozygous lines with distinct character combinations were derived. Dwarf doubled haploids derived from Ponni (indica) retained the panicle and grain type of their parents.

507 MERCY, ST. 1990. **Basic studies in rice anther culture.** *Basic research for crop disease management*/edited by P Vidhyasekaran. New Delhi: Daya Publishing House, p. 49-64; 83 ref.

The current status of work carried out on various aspects of rice anther culture is reviewed. Attention is given to the genotype and physical conditions of donor plants, pretreatments of flower buds prior to culture, the pollen development stage, culture conditions, media, position of anthers at plating, free pollen culture and the mechanism of androgenic initiation. Chromosomal variations, regeneration, albino plants, ploidy status and chromosome behaviour of regenerated plants and gametoclonal variability are discussed.

508 MIAH, AJ; AZAM, MA; HAKIN, L; MANSUR, MA; JALALUDDIN, M; BEGUM, N. 1991. **Improvement of rice through tissue culture techniques**. *Cereal Research Communications*, 19: 1-2, 195-199; 4 ref.

Of 5 semi-dwarf rice varieties used to induce callus on MS medium supplemented with sucrose, yeast extract and 2,4-D, BR3 callused best. Vigorously growing callus of BR3 produced multiple shoots on MS medium supplemented with NAA, kinetin, sucrose, yeast extract and casein hydrolysate. Nine regenerants from the callus of a single seed were transferred to pots. Progenies from these plants were tested in experimental plots for various agronomic traits in the R2 generation and for disease and insect pest reaction in the R3 generation. Phenotypic variation from the parent variety BR3 was observed for several agronomic characters including plant height, panicle length and grain size.

509 MIAH, MAA; PATHAN, MS; QUAYUM, HA. 1993. **Development of salt tolerant rice line through tissue culture**. *International Plant Tissue Culture Conference*. (Dhaka Univ., Dept. of Botany: Dec 19-21).

510 MURTY, PSS; MURTY, KS. 1983. **Reduction of spikelet sterility in rice adopting panicle explant culture technique**. *Agricul. Science Digest*, 3: 3/4, 167-169; 7 ref.

Addition of proline, histidine, lysine and ammonium sulphate to a sucrose medium in which panicle explants of 2 rice cv. were cultured, decreased spikelet sterility and increased mumber and weight of grains; proline was the most effective.

511 NILUFER H KARIM; BANIK, MITALI. 1992. **Tissue culture for rice improvement**. Bangladesh Association of Women scientists (BAWS), Dhaka.

512 PAUL, NK; GHOSH, PD. 1984. **Callus induction and plant regeneration from embryo tissues of rice**. *International Rice Research Newsletter*, 9: 2, 13.

Plantlets were regenerated from calluses induced from embryos of Palman 579 cultured on Murashige and Skoog medium containing appropriate growth substances (those used in each subculture are given). Meiotic analysis showed that these plants had a normal chromosome number. They survived transfer to the field.

513 PAUL, NK; GHOSH, PD. 1986. **In vitro selection of NaCl tolerant cell cultures in *Oryza sativa L.***. *Current Science*, 55: 12, 568-569; 12 ref.

Callus cultures of cultivars Kiran and Madhu were repeatedly subcultured on media containing increasing amounts of NaCl (0.5-3% w/v). After 45-50 subcultures, cell lines were selected which could tolerate NaCl concentrations of 1.5% (Madhu) and 1% (Kiran).

514 PAUL, NK; GHOSH, PD. 1984. **Regeneration of plantlets of *Oryza sativa L. cv. Kiran* from scutellar tissues**. *Proceedings of the Indian National Science Academy, B*, 50: 3, 332-336; 16 ref.

Cultures were grown from scutellar tissues of rice embryo on Murashige and Skoog (MS) nutrient medium containing 2,4-D. Shoot buds were formed from the central region of scutellar callus, when transferred to MS supplemented with IAA (2 mg/l) + coconut water (10% v/v) and casein hydrolysate (500 mg/l) and gave rise to plantlets. Meiotic analysis of the regenerated plants showed n=12. The plants were grown to maturity and their quantitative characters analysed. Histological examination of the organ-forming callus indicated de novo differentiation of shoot apex, leaf primordia, vascular strands and roots.

515 RAINA, SK; SATHISH, P; SARMA, KS. 1987. **Plant regeneration from in vitro cultures of anthers and mature seeds of rice (*Oryza sativa L.*) cv. Basmati-370**. *Plant Cell Reports*, 6: 1, 43-45; 12 ref.

Pollen plants were obtained from anther-derived calluses of the indica rice cv. Basmati-370. Anther-response (anthers producing pollen-derived calluses) and plant regeneration frequency from the pollen-derived calluses was very low. Donor plants which flowered at max./-min. temp. of 34.2/23.3°C gave a significantly higher anther-response to in vitro techniques, than did those which flowered at 29.1/16.4°. Somatic callus induction and subsequent plant regeneration were readily obtained from mature seed embryos. While 1 or 2 mg 2,4-D or 2,4,5-T/litre proved highly efficient for callus induction, 50 or 100 mg tryptophan/litre induced a high frequency of green plants from the calluses.

516 RAINA, SK. 1989. **Tissue culture in rice improvement: status and potential**. *Advances in Agronomy*, 42, 339-398; 8 p. of ref.

The role of in vitro culture methods in rice breeding is reviewed under the following headings: (1) embryo culture, (2) anther, pollen and ovary culture, (3) somatic cell culture, (4) protoplasts, and (5) overview and strategies for the future.

517 RANGASAMY, SRS; RAINA, SK; MANUEL, WW; NATARAJAMOORTHY, K; PALANISAMY, S; GURUNATHAN, M. 1989. **Performance of anther-derived lines**. *International Rice Research Newsletter*, 14: 2, 4-5.

Rice cultures 433A-R5 and 433A-R6 (2 of 7 anther derived lines from the F1s of Vaigai X Co40) showed 8.8 and 11.4% yield increases, respectively, over the Co43 control during July-October. Culture 433A-R6 was photoperiod insensitive (duration 134-137 days) while duration of the other cultures fluctuated by 11-20 days. All the cultures were semidwarf (57-76 cm) and had 6.9-7.7 panicles/hill. Grain in 6 cultures was short and bold while in 433A-R6 it was long and slender. Rice colour was white. Culture 433A-R1 was resistant to blast (Bl) [*Pyricularia oryzae*] and rice tungro virus (RTV), 433A-R5 was resistant to Bl and moderately resistant to RTV and bacterial blight (BB) (*Xanthomonas campestris pv. oryzae*) and 433A-R6 was resistant to Bl and moderately resistant to RTV, BB and brown spot (*Cochliobolus miyabeanus*).

518 REDDY, CS; VIDYASAGAR, G. 1988. **Callus induction and plantlet regeneration from immature panicles of rice**. *Genome*, 30: supplement 1, 464.

Among different explants, mature grains and mature embryos of both Tellahamsa and MTU2077 cultivars produced good callus while those of Tetraploid (basmati X Tellahamsa) produced moderate callus. Immature panicles of Tellahamsa alone produced callus. No callus initiation was observed in leaf, stem and root explants of any cultivars. MS medium containing 2,4-D (2 mg/litre) yielded a better response in terms of callus induction and growth than to LS [Linsmaier and Skoog] medium and other hormonal combinations. Morphogenetic studies of calluses from immature panicles of Tellahamsa showed a higher frequency of plantlet

regeneration in MS medium with kinetin (4 mg/litre) and IAA (4 mg/litre) (90%) or NAA (80%) and in LS medium with kinetin (2 mg/litre) and IAA or NAA (1 mg/litre) (60% each) compared to other hormonal combinations. The presence of 2,4-D in both media antagonized plantlet regeneration, but induced good callus growth and rhizogenesis. About 60% survived when regenerated plantlets were transferred to the field after hardening and all of them developed normally with good flowering and grain set.

519 REDDY, PJ; VAIDYANATH, K. 1986. **In vitro characterization of salt stress effects and the selection of salt tolerant plants in rice (*Oryza sativa L.*).** *Theoretical and Applied Genetics*, 71: 5, 757-760; 21 ref.

Embryo-derived callus was grown on solid Linsmaier & Skoog medium containing 0, 1 and 2% (W/V) NaCl for 24 days. Callus growth decreased markedly with increasing NaCl content. Proline content increased several-fold in salt-stressed callus. Only a small number of callus cells maintained healthy and stable growth, and these variants were subcultured every 3 weeks onto medium containing 1% NaCl. At the end of the third subculture, tolerant calluses were transferred to regeneration medium. Lines selected for salt tolerance showed a higher regeneration frequency than unselected lines.

520 REDDY, PJ; VAIDYANATH, K. 1985. **In vitro selection for salt tolerance in Basmati rice**. *Indian Journal of Plant Physiology*, 28: 1, 88-91; 10 ref.

In vitro selection for salt tolerance, using embryo-derived callus of rice cv. 27814, and its subsequent regenerated plants, was examined. Prolonged exposure of callus to a toxic concn. of NaCl (1%) led to arrested growth in most of the calluses. However, a small number of them maintained healthy and stable growth throughout the 3 selective passages, indicating tolerance to salinity. Plants were regenerated from such lines. The regeneration frequency in the lines selected for salt tolerance was 72% compared with 61% in unselected (control) lines.

521 REDDY, VS; LEELAVATHI, S; SEN, SK. 1985. **Influence of genotype and culture medium on microspore callus induction and green plant regeneration in anthers of *Oryza sativa***. *Physiologia Plantarum*, 63: 3, 309-314; 32 ref.

The 8 indica cultivars studied on 4 basal media showed genotype-dependent responses to nutritional requirements for anther culture with respect to the different media used. Induction of callus was higher on He2 and He5 media than on R3 or N6. He2 proved suitable for the cultivars ARC15570, Tetep, Govindobhog, Radhunipagal, Small Fruits and Meghna, but not for Mohini and Pankaj, for which He5 was best. Govindobhog and Small Fruits possessed wide adaptation to diverse nutritional conditions. Optimum conditions for callus induction included medium supplementation with sucrose at 3-5%, 9 μM 2,4-D, 0.3 μM picloram and 0.5 μM zeatin. Pretreatment of anthers at 35°C for 5 min followed by 10°C for 3 days was most suitable for callus induction and regeneration of green plants.

522 ROUT, JR; SARMA, NP. 1990. **Comparative morphological studies of microspore derived and F2 plants obtained from an interspecific rice hybrid (*Oryza sativa Linn.*. X *O. rufipogon Griff.*)**. *Plant Breeding*, 105: 4, 283-291; 16 ref.

Of 117 green plants regenerated by anther culture of this hybrid, 56 survived to maturity. Most of these plants were either haploids or doubled haploids and few were chromosomal variants. Compared with seed-derived F2 plants, androgenic plants, though few in number, showed greater variation for all traits except number of ear-bearing tillers and gave a high percentage of recombinants not seen in the F2. Androgenic plants of indica type with one or 2 traits introgressed from *O. rufipogon* were recovered.

523 ROUT, JR; SARMA, NP; RAO, GJN. 1989. **Effect of potato-2 medium on anther culture of interspecific rice hybrids**. *Annals of Botany*, 63: 6, 621-624; 10 ref.

The effect of 2 culture media, potato-2 and N6, supplemented with kinetin and either 2,4-D or NAA on the anther culture response of 2 interspecific rice hybrids was studied. Calluses were successfully induced and plants regenerated from the F1 of *Oryza sativa* X *O. rufipogon*, whereas *O. sativa* X *O. longistaminata* did not respond. Nevertheless, some success in callus induction was achieved in the latter when anthers from a few selected F2 plants were cultured. No interaction effects were observed between the media and growth hormones for anther response to callusing. Potato-2 medium proved to be superior to N6 in terms of anther response, early callus induction, multiple callus formation and overall green plant regeneration.

524 SHAHJAHAN, AKM; KARIM, NH; MIAH, SA. 1985. **Culture conditions and callus-forming ability of rice anthers**. *International Rice Research Newsletter*, 10: 3, 22.

The callus forming ability of anthers of 3 indica and

indica/japonica cv. and 4 F2 lines in 5 different media ranged from 0 to 25%. IR19660-311 and Pajam responded to all 5 media and an F2 line of BR7/Basmati 70 responded to 2 media. Medium N6 was less effective than the other media. Callus formation in Pajam anthers ranged from 0 to 6.9% in the light and 4.0-9.0% in the dark; the difference between the means was significant.

525 SHAHJAHAN, AKM; KARIM, NILUFER H; MIAH, SA. 1984. **Embryo grafting of rice varieties**. *International Rice Research Newsletter*, 9: 2, 12-13.

Embryos excised from grains of one cultivar were transferred to the endosperm (embryo removed) of another and cultured in vitro; 22 cultivar combinations were attempted. The best substrate for plant establishment was 0.7% water agar medium and the technique was only successful for embryos excised more than ten days after anthesis. Plants from cultured embryos resembled those from normal grains, except that they matured 10-15 days later. The best combination was BR4 plus BR9, with 50% seedlings surviving.

526 SHARMA, AN; SINHA, S; SINHA, U. 1989. **Amino acid analogue inhibited in vitro growth and development of excised embryos of rice**. *Phytomorphology*, 39: 4, 277-284; 28 ref.

Effects of 2 amino acid analogues, p-fluorophenylalanine (FPA) and ethionine, on in vitro growing excised rice embryos were studied. Both were inhibitory and there was a marked inhibition in the further growth of the plantlets. Chlorophyll content was adversely affected, ultimately leading to the loss of green colour of the treated plantlets. The extent of inhibition was proportional to the concn of these 2 antimetabolites. Ethionine was more effective than FPA. Growth retarding effect of the analogues was manifested at the macromolecular level also. There was a decrease in the amount of total DNA, proteins and carbohydrates of the treated tissues, indicating a disturbance in the complete metabolic system, ultimately leading to the differentiation of stunted plantlets. These antimetabolites also decreased the total activity of peroxidases. The reduced enzyme activity could be responsible for the imbalance leading to the observed retardation in the growth and differentiation of the cultured embryos. These findings indicated the possible exploitation of FPA and ethionine for the induction and selection of aneuploids and haploids in rice as well as in other angiosperms.

527 SHARMA, DR; DAWRA, S; CHOWDHURY, JB. 1983. **Direct and indirect effects of gamma rays on stimulation of morphogenesis in long term tissue culture of rice (*Oryza sativa L.*)**. *Current Science*, 52: 12, 606-607; 11 ref.

Segments of 1-wk-old rice roots cultured on Murashige and Skoog (MS) medium supplemented with 2 mg 2,4-D/l in the dark were recultured on a fresh medium at 1-month-intervals. The 8-month-old cultures, which had lost the capacity to differentiate shoots, were gamma-irradiated at 0.5-2 kR and transferred to MS medium under light. In another set irradiated and nonirradiated calluses were transferred to the medium also irradiated at the same doses. Irradiation of the callus and/or the medium stimulated plant regeneration; callus irradiation at 1 kR was the most effective.

528 SHARMA, DR; CHOWDHURY, JB; DAWRA, S. 1983. **Plant regeneration in long term tissue cultures of rice A model system**. *15th International Cong. Genet.* (New Delhi: 1983: December 12-21). p. 427.

529 SIDDESWAR, G; KISHOR, PBK. 1989. **Plant regeneration from polyethyleneglycol adapted callus of rice**. *Current Science*, 58: 16, 926-928; 10 ref.

Callus cultures of varieties Tellahamsa and Sureka (susceptible to water stress) were initiated from mature embryos on Linsmaier & Skoog medium containing 2 mg 2,4-D/litre and 2% sucrose. Calluses were transferred after 6 subcultures to medium containing 10, 20, 30 or 50 g polyethylene glycol (PEG)/litre. After 6 subcultures on these media, regenerative ability was tested on medium containing 10 g PEG/litre. Best results were obtained from calluses conditioned to PEG at 20 g/litre. Control calluses (no PEG) failed to regenerate in the presence of PEG.

530 SUBHASHINI, K; REDDY, GM. 1991. **Role of proline in callus growth and plant regeneration under salt stress in rice**. *Proceedings of the Indian National Science Academy. Part B, Biological Sciences*, 57: 1, 81-83; 13 ref.

The effect of 5 mM L-proline on mature, embryo-derived callus of the salt tolerant cv. SR26B at 3 NaCl and 3 sea water concentrations was investigated. Proline increased callus weight and frequency of regeneration under low but not high salt stress levels.

531 VIDHYASEKARAN, P; BORROMEO, ES; LING, DH; MEW, TW. 1991. **Relationship between growth rate of *Helminthosporium* oryzae isolates on calluses of rice cultivars and their disease reaction on rice plants**. *Plant Cell, Tissue and Organ Culture*, 24: 3, 237-241; 23 ref.

Of the 202 isolates of *H. oryzae* [*Cochliobolus miyabeanus*] tested for their pathogenicity, only isolates I 34, I 36, I 47 and I 202 showed differential reaction on rice cultivars IR 8, TN 1, CH 45 and Co 20. Compatible isolates grew faster than uncompatible isolates on the 4 cultivars. The difference in reaction of calluses to the different isolates was more discernible on the 3rd day after inoculation and after 7 d no differences could be observed in the reaction of calluses to different isolates. Inoculum concn and size of callus also influenced the reaction of the callus. Rice calluses and whole plants behave similarly in response to *C. miyabeanus* inoculation and selection of resistant calluses in vitro to produce resistant plants may be a possibility.

Anther culture

532 BALACHANDRAN, SM; HOAN, NT; GARG, AK; SIDDIQ, EA; SHARMA, NP. 1994. **Anther and somatic cell culture studies in rice.** *Presented in the Third Annual Meeting of national Rice biotechnology Network at MSSRF*. (Madras, Tamil Nadu, India: 1994: March 3-5). p. 7-8.

533 BALACHANDRAN, SM; GUPTA, JN; SAILAJA, M; SARMA, NP. 1994. **Somatic and anther culture response of some wild rices and land cultures**. *Presented in the International satellite Symposium on Plant Biotechnology Applications*. (Hydreabad, AP, India: 1994: September 16-18).

534 MIAH, MAA; KHUSH, GS. 1984. **A study on the effect of liquid medium in anther culture of rice (*Oryza sativa L.*)**. *Bangladesh Journal of Botany*, 13: 1, 112-113.

535 MIAH, MAA; EARLE, ED; KHUSH, GS. 1985. **Inheritance of callus formation ability in anther culture of rice (*Oryza Sativa L.*)**. *Theoretical and Applied Genetics*, 70: 113-116.

536 MIAH, MAA. 1983. **Innovative approaches in plant breeding - application of anther culture in rice improvement**. *Proceedings of the First National Symposium on Agricultural Research*. (BARC, Dhaka: 1983: Dec 22-23).

537 MIAH, MAA; EARLE, ED. 1985. **Performance and uniformity of rice lines obtained by anther culture of an F1 hybrid**. *Bangladesh Journal of Botany*, 14: 1, 47-55.

538 NARASIMMAN, R; RANGASAMY, SR. 1993. **Comparison of fertility between the F1, F2 and anther derived lines in the crosses of indica/japonica and japonica/indica in rice (*Oryza sativa L.*)**. *Euphytica*, 66: 1-2, 19-25.

539 RAINA, SK; BALACHANDRAN, SM; VIRMANI, SS; ZAPATA, FJ. 1989. **Improved medium for efficient anther culture of some indica rice hybrids.** *IRRN*, 14: 3, 4.

540 RANGASAMY, SR; MANUEL, WW; NATARAJAMOORTHY, K; PALANISAMY, S; GURUNATHAN, M. 1988. **Variations in anther culture-derived lines of Ponni**. *International Rice Research Newsletter*, 13: 4, 4.

A study of 10 lines in a randomized block design at Coimbatore showed a large reduction in days to flowering (107-110), plant height (79-84 cm) and grain yield (3.8-5.3 t/ha), but increased 1000-grain weight (17.1-17.6 g) compared to Ponni (122 days, 121 cm, 7.0 t/ha and 14.8 g, respectively). It is suggested that the lines could be used for breeding for short stature in rice.

541 SANDHU, JS; GILL, MS; GOSAL, SS. 1993. **Callus induction and plant regeneration from cultured anthers of indica rice varieties**. *Plant Tissue Culture*, 3: 1, 17-21.

Anthers containing pollen at late uninucleate stage from cold pretreated panicles at 4-5 deg. C for 7 days of three varieties viz. Jaya, IR 54 and Vaigai were cultured on N6 medium supplemented with various combinations and concentrations of auxins, cytokinins and sucrose. The best callusing from cultured anthers occurred on N6 medium containing 2, 4-D (1.75 mg/l), Kn (0.5 mg/l), sucrose (3% w/v) ranging from 1.75 per cent in Jaya to 2.25 per cent in IR 54. Upon transfer to N6 medium supplemented with BAP (0.5 mg/l) and sucrose (4.5% w/v) anther-derived calli differentiated into shoots ranging from 15% in Jaya to 24% in IR 54.

542 SARMA, NP; ROUT, JR. 1987. **Plant breeding considerations of anther culture use in rice improvement**. *Abstracts. First symposium on crop improvement*. (Ludhiana, India: 1987:23-27 February)/edited by KS Gill, AS Khehra, MM Verma, KS Bains. Crop Improvement Society of India, Ludhiana, India. p. 160.

Spontaneous doubled haploids from anther culture of the cross MG162 X Mahsuri showed variations in hull colour, growth period and sterility in segregating progenies which were not observed in the F2 raised from the F1 of the same cross. To avoid the instability

associated with spontaneous doubling of haploids, artificial doubling is advocated.

543 SHAHJAHAN, AKM; NILUFER H KARIM; NAHAR, MAKSUDA A; HAQUE MZ; MIAH, SA. 1992. **Callus induction and regeneration in rice through anther culture of rice (*Oryza sativa*. L).** *Bangladesh Journal of Botany*, 21: 2.

544 SHAHJAHAN, AKM; NAHAR, MA; NILUFER H KARIM; MIAH, NM. 1992. **Evaluation of rice dihaploids derived through anther culture.** *Plant Tissue Culture*, 2: 1.

Propagation

545 MUSTAFA, MG; MIAH, MAA. 1988. **Callus formation and regeneration ability of some indica rice (*Oryza sativa L.*).** *Bangladesh Journal of Botany*, 1: 47-53.

546 NILUFER H KARIM; HAQUE, MZ. 1994. **Mannitol and proline for improved regeneration of rice (*Oryza sativa L.*) anther callus.** *International Plant Tissue Culture Conference*. (Dhaka Univ., Dept. of Botany: December 19-21)

Embryogenesis

547 CHOWDHRY, CN; TYAGI, AK; MAHESHWARI, N; MAHESHWARI, SC. 1993. **Effect of L-proline and L-tryptophan on somatic embryogenesis and plantlet regeneration of rice (*Oryza sativa L. cv. Pusa 169*).** *Plant Cell, Tissue and Organ Culture*, 32: 3, 357-361.

548 NILUFER H KARIM; ZAPATA, FJ. 1994. **Efficient embryogenesis in rice.** *Pakistan Journal of Agricultural Research*,

549 NILUFER H KARIM; ZAPATA, FJ. 1991. **Embryogenesis in rice.** *Plant Tissue Culture Conference*. (BINA, Mymensingh: 1991: Dec. 7-9).

550 SHARMA, DK; KATIYAR, SK; SHRIVASTAVA, MN. 1991. **In vitro regeneration through somatic embryogenesis in some popular varieties of rice.** *National Symposium on role of biochemistry and Biotechnology as crop production*. (New Delhi: 1991: November 18-19). Directorate of Research Services, Indira Gandhi Krishi Vishwa Vidyalaya, Raipur- 492 012 (M.P.).

Diseases

551 DAHAL, G; DASGUPTA, I; LEE, G; HULL, R. 1992. **Comparative transmission of, and varietal reaction to, three isolates of rice tungro virus disease.** *Annals of Applied Biology*, 120: 2, 287-300; 35 ref.

Comparative transmission by leafhoppers (*Nephotettix virescens*) of 3 tungro isolates obtained from the Philippines, India and Malaysia, and of an infectious clone of the Philippine isolate of rice tungro bacilliform badnavirus (RTBV) by agroinoculation, was conducted on 12 rice cultivars. The symptoms, including height of inoculated plants were recorded and the efficiency of RTBV and rice tungro spherical machlovirus (RTSV) transmission was determined by ELISA. In most cases, the reduction of height and leaf symptoms of plants infected with RTBV and/or RTSV by the 3 isolates were similar in any given cultivar. On cultivar ASD 7, the Malaysian isolate showed more severe yellow orange leaf discolouration symptoms than the Indian isolate which in turn had more severe leaf discolouration than the Philippine isolate. On the other hand, cultivars ASD 7 and Ptb 18 produced the most severe yellow orange leaf discolouration when agroinoculated with an infectious RTBV clone of the Philippine isolate. There was some variation in the transmission profile of the 2 tungro viruses among the 3 isolates. However, there was no one clear set of characteristics by which one could use cultivars to distinguish isolates. The amount of viral DNA in agroinfected plants of cultivars Utri merah, Balimau putih, Utri Rajapan and ARC 11554 was low, while the amount was high in cultivars TN1, ASD7, Ptb 18 and TKM 6. There was high correlation between the amount of viral coat protein by ELISA and viral nucleic acid by DNA hybridisation on 10 agroinoculated rice cultivars; this might indicate that similar proportions of the total RTBV DNA are encapsidated in each cultivar.

552 DEVADATH, S. 1984. **A step towards breeding for absolute resistance to bacterial blight of rice.** *Rice Research Newsletter*, 5: 3/4, 4-5.

A strain of *Oryza longistaminata* with absolute resistance to bacterial leaf blight [*Xanthomonas oryzae*] was identified and crossed as male parent to *O. sativa* lines PR106, Jaya and CR208-1208. *O. longistaminata*, which is also resistant to bacterial leaf streak blast [*X. translucens f. sp. oryzicola*] and tungro virus, is rhizomatous and perennial with a grain-shattering habit, and has the AA genome. Resistance to *X. oryzae* was recessive. All the F1 progeny showed shattering, and sterility occurred to differing extents in the progeny of all cross combinations. The crosses with PR106 and

Jaya showed high photosensitivity and did not flower in the dry season, but all 3 F1s flowered in the wet season.

553 MAJI, SK; GUPTA, PKS. 1986. **Some factors affecting toxin production by the rice leaf scald fungus, *Rhynchosporium oryzae*, and its activity**. *Indian Journal of Plant Pathology*, 4: 1, 63-66; 4 ref.

The mycotoxin from *R. oryze* [*Monographella albescens*] was host-specific. Of 6 media tested, cell free culture filtrates of potato dextrose broth amended with 2% rice straw extract were highly toxic to rice seedlings. This filtrate was also slightly toxic at a 5% dilution. The toxic effect was evident at 5°C and increased with increasing temp. The effect was more marked on older seedlings. Of 5 gramineous hosts tested, only rice was affected by the filtrate. Pea and tomato showed a very low degree of phytotoxicity.

554 MANIAN, S; PAULSAMY, S. 1987. **Biological control of sheath blight disease of rice**. *Journal of Biological Control*, 1: 1, 57-59; 10 ref.

Trichoderma aureoviride restricted the in vitro mycelial growth and sclerotial initiation of a virulent isolate of *Rhizoctonia solani* by 52.7 and 95.3%, respectively. Microscopic examination revealed that >25% of the *R. solani* mycelium near the inhibition zone was lysed and most of the hyphal tips showed bulb-like terminal enlargements. In pot culture, soil amendment with *T. aureoviride* reduced the incidence and severity of sheath blight in TKM-9 rice.

555 PADHI, B; CHAKRABARTI, NK. 1984. **Changes in nucleic acid contents in rice plants inoculated with *Pyricularia oryzae***. *Phytopathologische Zeitschrift*, 109: 4, 372-375; 13 ref.

Seedlings of the 8 international blast differential rice cultivars and cultivar Co.13 (highly susceptible) were inoculated with 2 races of *P. oryzae*. After 10 days, RNA and DNA were extracted from the leaves and estimated. RNA contents were reduced by infection, the decrease being greater with race IE-2 than with IC-22, and with susceptible than resistant cultivars. DNA contents were significantly increased by inoculation with either race, increases being greatest in susceptible cultivars. No clear-cut differences were found between RNA or DNA contents of healthy plants.

556 SAKTHIVEL, N; GNANAMANICKAM, SS. 1986. **Bacterization of rice with *Pseudomonas fluorescens* reduces sheath rot (ShR) infection**. *International Rice Research Newsletter*, 11: 3, 17-18; 1 tab.

P. fluorescens isolated from citrus restricted growth of the sheath rot pathogen, *Sarocladium oryzae* in culture. In glasshouse tests, treating *S. oryzae* inoculated plants with *P. fluorescens* restricted the development of sheath rot lesions. Plants sprayed with *P. fluorescens* in the field showed substantially reduced sheath rot severity and increased grain yield.

557 SAKTHIVEL, N; GNANAMANICKAM, SS. 1987. **Evaluation of *Pseudomonas fluorescens* for suppression of sheath rot disease and for enhancement of grain yields in rice (*Oryza sativa L.*)**. *Applied and Environmental Microbiology*, 53:9, 2056-59; 20 ref.

Imprints of seedlings and a direct-observation technique of staining roots with fluorochromes confirmed the association of *P. fluorescens* with roots and the ability of the str. to move along shoot tips. In greenhouse tests, *P. fluorescens-treated* rice plants (cv. IR 20) showed a 54% reduction in the length of sheath rot (*Sarocladium oryzae*) lesions. In 3 field tests, treatment with *P. fluorescens* reduced disease severity by 20 to 42% in 5 rice cultivars. Bacterization enhanced plant height, number of tillers and grain yields from 3 to 160%

558 SANTHI, DP; UNNAMALAI, N; GNANAMANICKAM, SS. 1987. **Epiphytic association of *Erwinia herbicola* with rice leaves infected by *Xanthomonas campestris pv. oryzae* and its interaction with pathogen**. *Indian Phytopathology*, 40: 3, 327-332; 9 ref.

Of 7 isolates of epiphytic bacteria from healthy rice leaves (cultivar CO 43) and leaves infected with bacterial leaf blight, 5 were Gram-negative, facultative anaerobes and were identified as *E. herbicola*. In in vitro tests, these isolates were antagonistic to *X. campestris pv. oryzae*. Their suppressive effect on the pathogen was due to their ability to lower the pH of the medium to levels unsuitable for the growth of *X. campestris pv. oryzae*. Suppression of bacterial blight symptoms occurred in rice leaves inoculated with a mixture of *E. herbicola* and *X. campestris pv. oryzae* cells but not in leaves inoculated with the pathogen alone.

559 SHUKLA, SN. 1988. **Save your rice crop from pests and diseases**. *Indian Farming*, 38: 2, 13-16.

Notes on the important pests and diseases of rice are given with details of the symptoms of damage caused and their control (including chemical, cultural and biological control and the use of resistant varieties).

560 SIDHU, GS; BHARAJ, TS. 1992. **Inheritance of resistance to Kresek phase of bacterial blight disease of rice**. *J. of Genetics and Breeding*, 46: 2, 199-201.

More than 200 varieties of rice, *Oryza sativa L.*, were

evaluated for resistance to the Kresek and blight phases of bacterial blight disease by using the Indian Punjab isolate of the pathogen, *Xanthomonas campestris pv. oryzae*. Varieties PAU 212, BJ 1, DV 86, DZ 78, Kalimakri 77-5, Chinsurah Boro II and AC 19-1-1 were resistant to the Kresek as well as blight phase of the disease. Nagane Tia, Nam Sakouy, Nam Sagui 19, Patong 32, Lua Ngu and PI 231129 were susceptible to the Kresek phase but showed strong resistance to the blight phase. Resistant varieties PAU 212, BJ1, DV 86 and DZ 78 were crossed with the susceptible variety Taichung Native 1. Reaction to the Punjab isolate of the F1, F2 and F3 progenies of these crosses showed that resistance to the Kresek phase in PAU 212, BJ 1, DV 86 and DZ 78 was governed by complementary gene action of two resistance genes which were independently inherited.

561 VIJAI PAL; GARDAN, L; CHARLES, M; PAL, V. 1988. **Isolation of a plasmid from strains of *Xanthomonas campestris pv. oryzae* that cause bacterial blight (BB) in rice**. *International Rice Research Newsletter*, 13: 2, 10.

A plasmid of MW 20.3 X 106 to 21 X 106 dalton was isolated from 4 strs of *X. campestris pv. oryzae*, 2 from the collection at INRA, Angers, France, and 2 from Haryana Agric. Univ. The same plasmid was reisolated from infected seedlings after 5 serial inoculations with the test strs of *X. campestris pv. oryzae*.

Insect pests control

562 JOSHI, RC; CADAPAN, EP; HEINRICHS, EA. 1987. **Natural enemies of rice leaf folder, *Cnaphalocrocis medinalis* Guenee (Pyralidae: Lepidoptera) - a critical review (1913-1983)**. *Agricultural Reviews*, 8: 1, 22-34; 69 ref.

The biological control agents of *Cnaphalocrocis medinalis*, a pest of rice, which were recorded between 1913 and 1983 are reviewed. The egg parasitoid *Trichogramma sp.* has been used successfully in China, India and Japan. The ichneumonid *Trathala flavoorbitalis*, the braconid *Apanteles sp.*, the chalcidid *Brachymeria excarinata* and the bethylid *Goniozus indicus* have also been recorded as parasitoids of *C. medinalis*. Predators which are known to attack *C. medinalis* include formicids such as *Pheidole sp.*, *Solenopsis geminata* and *Diacamma*, the carabid *Chlaenius sp.*, *Coccinella arcuata* [*Harmonia octomaculata*], and the spiders *Lycosa pseudoannulata* and *Tetragnatha japonica*. The entomogenous fungi *Beauveria bassiana*, *Syncephalastrum racemosum* and *Penicillium oxalicum* are among the pathogens of *Cnaphalocrocis medinalis*. *Bacillus thuringiensis* and *Serratia marcescens* and a granulosis virus also have potential as microbial biocontrol agents. *Neoaplectana carpocapsae* is the only parasitic nematode which has been reported in *C. medinalis*.

563 PHILIP, BM; NAIR, KPV. 1990. **Exposure of white mice, white rats and embryonated chick eggs to nuclear polyhedrosis virus of rice swarming caterpillar, *Spodoptera mauritia (Boisduval)***. *Indian Journal of Entomology*, 52: 4, 622-626.

Other aspects of Rice

564 DAWRA, S; SHARMA, DR; CHOWDHURY, JB; JAIN, RK. 1982. **Studies on growth and differentiation in cultured cells of rice (*Oryza sativa*)**. *Plant Cell Culture in Crop Improvement* /edited by SK Sen and KL Giles. New York: Plenum Press, p. 445-450.

565 HAQUE, ME; MIAH, NM; ZEENAT, Z; QUADER, B. 1989. **Genetic diversity in three groups of rice**. *Bangladesh Journal of Plant Breeding and Genetics*, 2: 1-2, 49-54.

Divergence analyses were performed in 20 rice varieties/lines each, from traditional cold tolerant indica, cold tolerant modern varieties/lines and japonica varieties. The study was made to observe the extent of genetic diversity within each group and to identify diverse genotypes to generate crosses that give transgressive segregants in later generations. Wide range of diversity was obtained in modern varieties/lines and in japonica varieties. Parents could be selected from different clusters for hybridization to obtain heterotic segregants.

566 REDDY, KRK; RAO, AH; SREE, BK; REDDY, AR. 1993. **Water stress-induced 23kDa polypeptide in cell suspension cultures of rice (*Oryza sativa L.*) is immunologically similar to that of seedlings**. *Journal of Plant Physiology*, 141: 3, 373-375.

GRAIN LEGUMES

567 GILL, RAVINDER. 1990. **Direct gene transfer in *Psophocarpus tetragonolobus* resistance to kanamycin**. *Annals of Botany*, 66: 1, 31-39; 34 ref.

Epicotyl-derived protoplasts were isolated and transformed to kanamycin resistance following uptake of plasmid (pABD1 or pHP23) DNA in combination with polyethylene glycol treatment. Protoplast-derived transformed colonies were selected on media containing kanamycin (75 mg/litre). The transformed calluses