

BHABHA ATOMIC RESEARCH CENTRE**Nuclear Agriculture & Biotechnology Division, Mumbai-400085, India.*****Induced mutation studies in Indian wheat using electron beam irradiation.***

G. Vishwakarma, Vikas, A. Shitre, and B.K. Das, and V.C. Petwal (Raja Ramanna Centre for Advanced Technology, Indore, India).

Induced mutations using gamma rays commonly are used for improvement of agronomic and other characters in crop plants. In Indian wheat, gamma ray-induced mutations commonly are used. However, other physical mutagens, i.e., X- rays, electrons, protons, and ion beams, have reported producing novel and useful mutants. We initiated a study, in collaboration with the Raja Ramanna Centre for Advanced Technology, Indore, to observe the effects of electron-beam irradiation on germination and early seedling growth. Three wheat cultivars, MP3054, Unnath C306, and NIAW301, were irradiated with e-beam doses of 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650, 700, and 750 Gray. Seeds were sown in controlled growth chambers. Observations were taken 15 days after sowing. GR50 and LD50 are being studied with replication. Once the doses are standardized, we will proceed to irradiate bulk seed for a mutation-breeding approach for developing mutants having useful traits, such as earliness, reduced height, low PPO, low phytic acid, and rust resistance.

Identification of novel mutants in Indian wheat using gamma ray irradiation.

Vikas, G. Vishwakarma, A. Shitre, and B.K. Das, and G.A. Gadekar (Agriculture Research Station, Niphad, India).

For improvement of agronomic traits and rust resistance, popular wheat cultivars of the Peninsular zone (NIAW917, NIAW 34, and NIAW301) were irradiated with Gamma rays. Approximately 700 seeds were irradiated with three doses (250, 300, and 350 Gray). In the M_1 generation, 600 seeds/dose were sown, which had 40–50% germination. In a rare event, we obtained double-spike, putative mutants in the M_1 generation in these cultivars. In another experiment, in the cultivar HD2189, a putative mutant with two tillers at the early seedling germination stage also was obtained in the M_1 . Seeds from individual plants were harvested, and these will be grown in the M_2 generation for further confirmation and stabilization.

Molecular characterization of an early mutant line in the wheat cultivar C-306; a study of inheritance and identification of molecular markers for earliness.

G. Vishwakarma, Vikas, A. Shitre, and B.K. Das.

In our earlier experiment, we identified early mutants in the background of the Indian wheat cultivar C-306, known for its excellent Chapati-making quality. The mutant was 25 days earlier than the C-306 parent. We are now in the process of characterizing these mutants using AFLP- and AP-PCR-based molecular markers. We also are developing a mapping population for tagging the mutant allele(s) for earliness. Crosses were made between the mutant line (TWM-89-2) and C-306. The F_1 seeds were harvested and the population is being advanced for studying inheritance in the F_2 onwards. Genetic polymorphism also is being studied among the parent and mutant using molecular markers. The mutants also were evaluated at different geographical locations to study the effect of environment on the mutant trait.

Use of mutation and molecular techniques for improvement of earliness and rust resistance in the wheat cultivar C-306.

Vikas, G. Vishwakarma, S.G. Bhagwat, and B.K. Das.

C-306 is an excellent cultivar for Chapati-making quality. However, the cultivar is of long duration, which is affected by terminal heat stress, and is susceptible to rust. In order to improve these traits, induced mutation studies were undertaken. A 25-day, early mutant was identified in a gamma ray-mutagenized population. The mutant later was crossed with Unnath C306 (C306+*Sr24/Lr24*) and selections for earliness and rust resistance were made in the F_2 . Rust resistance in a segregating population was screened by using a SCAR marker for *Sr24* and also confirmed using phenotypic observation of plant reaction to stem rust spore injection. The early and rust resistant plants were selected and, in the F_3 , earliness and rust resistance were confirmed. We have identified a few plants that are early and have rust resistance. These lines will be further evaluated and used in breeding programs.

Validation and use of DNA markers for rust resistance genes and quality traits for improvement of Indian wheat.

B.K. Das, G. Vishwakarma, Vikas, A. Shitre, Suman Bakshi, and S.G. Bhagwat.

In our efforts for improvement of Indian wheat for rust resistance and quality traits, we are using molecular markers in addition to conventional plant breeding approaches. The molecular markers for rust resistance genes (*Sr24/Lr24*, *Sr26*, *Sr2*, *Sr25*, *Sr31*, *Lr34*, and *Lr32*) were validated and are being used in our breeding programs. A marker for *Glu-D1d* (coding for HMW subunits 5+10), an important trait related to flour quality, also was validated and being used in marker-assisted selection in our populations. Selections have been made from different inter-cultivar crosses using some of these markers. We now have a few selections with these traits, and those are in advanced generations and being evaluated at different locations.

Studies to develop high-temperature stress tolerance in wheat: transfer of the reduced-height gene, *Rht8*, and its agronomic evaluation in a high-temperature environment .

Suman Bakshi, S.G. Bhagwat, and B.K. Das.

An agronomically desirable plant type with tolerance to heat has become a necessity for sub-tropical wheat areas. Our earlier studies indicated that a 192-bp allele of the WMS261 marker was observed in Indian cultivars; however, it was not associated with height reduction or any yield advantage, indicating that the *Rht8* gene may be absent in Indian cultivars. To transfer the *Rht8* gene linked to WMS261, crosses were made between a donor parent and the tall cultivars MP3054 or Ajantha. In a cross with MP3054, the F_2 segregants with the 192-bp allele showed a significant height reduction and a higher spikelet density over the 174-bp allele. In a cross with the tall parent Ajantha, plants with a 165-bp allele have a culm height of 64.1 ± 0.79 and a plant height of 73.7 ± 0.87 , whereas plants with the 192-bp allele have a culm height of 49.5 ± 0.94 and a plant height of 58.0 ± 1.06 . Genotypes with the 192-bp allele showed average culm height reduction of 23% and a plant height reduction of 21.3% over those with the 165-bp allele. Further evaluation of genotypes with the 192-bp allele associated *Rht8* under high temperature will give more information for suitability of this gene in warmer areas.

Studies to develop high-temperature stress tolerance in wheat: canopy temperature depression measurements to select physiologically more efficient genotypes under high temperature.

Suman Bakshi, A. Shitre, S.G. Bhagwat, and B.K. Das.

Canopy temperature depression (CTD) is a well-established method to identify physiologically competent genotypes under stress conditions. However, the significance of this technique to understand the plant's capability to tolerate heat stress is not explored in wheat. Canopy temperature depression is an expression of the number of morpho-physiological

traits and is characteristic of each cultivar. We designed an experiment to determine CTD differences among genotypes and the optimum growth stage and time for CTD measurements for detecting genotypic differences under heat stress. The experiment, at the Gamma Field, Trombay, measured the canopy temperature of 17 cultivars in 2009–10. Genotypes were sown in randomized block design with four replicates. Regional climatic data for crop season was collected from the observatory. Canopy temperature depression readings were taken by an infrared thermometer (TI200). The canopy temperature measurements were made between 12:00 to 2:00 PM. Five readings were taken for each replicate. The CTDs were taken at growth stages tillering, boot, anthesis, and maturity. Air temperatures also were observed in the field at time canopy temperatures were measured. The mean air temperature varied from 32 to 36.5°C during the days of measurement. Significant genotypic differences were observed for CTD from the air temperature at all growth stages. The average CTD over the season ranged from 14.4°C for genotype HD2687 to 9.9°C for Raj4037. Genotypes in early stages (tillering and boot) showed a greater decline in canopy temperature compared to genotypes at anthesis and seed setting. The CTD experiment was repeated in the winter of 2010–11 to determine the reproducibility of results. Twelve cultivars with early, medium, and long maturity were used. Initial results indicated significant differences within and among the groups. Further analysis and association with field data will help in ascertaining the genotypes maintaining low CTD and better performers under heat stress.

Studies to develop high-temperature stress tolerance in wheat: dry matter accumulation and mobilization efficiency of bread wheat cultivars in warm environment.

Suman Bakshi, Vikas, S.G. Bhagwat, and B.K. Das.

The grain yield of wheat is adversely affected by high-temperature stress in warm environments. Grain filling is preceded by two processes, dry matter accumulation and its translocation to the developing grain. These processes become more important when the wheat plant experiences high temperature stress during grain filling. Eight bread wheat cultivars were evaluated for dry matter accumulation and mobilization to the grain in warm environments for 2 years. The genotypes were planted in a randomized manner with five replications. Two tillers from each replication were cut from the base after ear emergence and to maturity at 10-day intervals. The tillers were separated into stem, leaves, chaff, and grain, air dried and weighed. The difference in the maximum dry weight and dry weight at harvest was used as the translocated amount. The results showed significant differences among genotypes for dry weight accumulation at the different growth stages. Among all the genotypes analyzed, HUW206 had the highest dry matter accumulated in both years (2011 and 2012). For the rate of mobilization of dry matter from stem, the cultivar WH542 was followed by HUW206 (25.5 and 22.0%) and PBW435 (20.7 and 21.3%) in years 2011 and 2012, respectively. Among the genotypes analyzed for dry matter mobilization, WH542, HD2687, HUW206, and PBW343 carried the T1B·1R translocation and Sonalika, PBW435, HD2189, and Ajantha did not. Among the T1B·1R group, HUW 206 showed the highest dry matter accumulation (634 mg (2011) and 529 mg (2012)), higher mobilization (58.6% (2011) and 56.1% (2012)), and highest grain yield/plot (117.0 g). Among the non-T1B·1R group, PBW435 had the highest dry matter accumulation (309 mg (2011) and 417 mg (2012)), higher mobilization (50.5% (2011) and 62.0% (2012)), and the highest grain yield/plot (279.6 g). This study showed differences among the genotypes for dry weight accumulation and mobilization in a warm environment. Optimization of both the processes will be desirable to enhance grain yield under heat-stress conditions.

News from our wheat research group.

Mr. Gautam Vishwakarma joined our wheat research group as a scientist after completion of a 1-year orientation course in Bioscience. He is working on using induced mutations and molecular markers for wheat improvement and understanding the mechanism of rust resistance genes in wheat.

Dr. S.G. Bhagwat, who led our wheat research group as Head of the Mutation Breeding Section, retired from Government service on superannuation.