International Conference on

Crop Production under Changing Climate in Bangladesh: Agronomic Options

ABSTRACTS

Date: October 6~7, 2010 (Wednesday and Thursday)

Venue: BARC Auditorium
Bangladesh Agricultural Research Council
Farmgate, Airport Road, Dhaka 1215

Bangladesh Society of Agronomy

(Website: http://bdagron.webs.com/)

International Conference on
Crop Production under Changing Climate in Bangladesh: Agronomic Options

Sub-Themes

a) Climate change –crop production & rural livelihoods
b) Coping with Drought and water management
c) Risk management in crop production- associated with rainfall, flood and submergence
d) Salinity and climate resilient cropping systems for the coastal areas

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1. SCREENING OF MUNGBEAN GENOTYPES FOR DROUGHT TOLERANCE

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The experiment was conducted at the Regional Agricultural Research Station of Bangladesh Agricultural Research Institute, Ishurdi, Pabna during early kharif season of 2009 to select suitable mungbean genotype for drought tolerance. The experiment was laid out in a RCB design with three replications. Eighteen genotypes of mungbean were screened for drought tolerance. The genotypes were sown on 24 March 2009 and harvested on different times (55-65 DAE) according to maturity. Pre sowing irrigation was applied for ensuring seed germination afterward the crop was subjected to drought. The same genotypes were grown in normal condition where two irrigations applied at 15 and 30 DAE for calculation drought indices. The results revealed that lines, BMX 01007, BMX 01015 and MBX90009-6 performed better for drought tolerance in respect of relative yield (71.37-73.35%), stress tolerance index (0.76-0.80) and stress susceptibility index (0.77-0.82). Relative water content of leaf was also higher (93.33-96.55% at 27 DAE and 83.61-87.11% at 33 DAE) in those lines and it was positively correlated with the seed yield (r=0.33-0.46 at p=0.05). The selected lines, BMX 01007, BMX 01015 and MBX90009-6 produced better seed of 1112, 1123 and 1159 kg/ha respectively.

2. SCREENING OF WHEAT GENOTYPES GROWN UNDER WATER STRESS CONDITION

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A pot experiment was conducted at Bangladesh Agricultural Research Institute, Joydebpur, Gazipur during 2005-2006 to evaluate the performance of wheat genotypes grown under water deficit condition. A total of 60 wheat genotypes collected from CIMMYT and WRC, BARI were grown with two soil moisture regimes viz. 50% Field Capacity (severe stress) and 100% Field Capacity (no stress). Plant height, tillers per plant reduced significantly due to soil moisture stress. Total dry matter per plant and grain yield per plant also reduced drastically due to water stress. However, a wide range of variation was observed among the wheat genotypes in this regard. Based on total dry matter production, grain yield and drought indexing parameters- dry matter stress index (DMSI), yield stability (YS) and drought susceptibility index (DSI) the genotypes were classified as tolerant, moderately tolerant, moderately susceptible and susceptible group. A few genotypes- V42, V16 and V60 performed better under water stress condition and fell into tolerant group. Similarly, V6, V36, V56 and V41 belong to moderately tolerant and V29, V28, V30, and V4 fell under susceptible group. However, most of the wheat genotypes were found moderately susceptible to drought in this study.

3. SPACING AND NITROGEN-PHOSPHORUS REQUIREMENT OF DWARF PEGIONPEA FOR RAINFED CULTIVATION

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The experiment was conducted at the Pulses Research Centre, Ishurdi, Pabna during the growing season of 2008-2009 to find out the optimum spicing and nitrogen-phosphorus (NP) level for higher yield of pegionpea in rainfed condition. The experiment comprised of four spacing viz. 20 cm × 15 cm (S_1), 20 cm × 20 cm (S_2), 30 cm × 20 cm (S_3) and 40 cm ×20 cm (S_4) and four nutrient levels viz. 0-0 kg/ha of N-P (L_1) 20-25 kg/ha of N-P (L_2), 30-35 kg/ha of N-P (L_3) and 40-55 kg/ha of N-P (L_4). The experiment was laid out in a split-plot design assigning spacing in the main plot and nutrient level in the sub plot. The crop was sown on 5 October 2008 and harvested on 24 March 2009. The highest branches/plant (6.54) and pods/plant (54.44) were observed in 40 cm × 20 cm (S_4) but the highest seed yield (1212-1237 kg/ha) was obtained from 20 cm × 15 cm (S_1)cm and 20 cm × 20 cm (S_2). Seed yield (1333 kg/ha) and yield components were the highest in 40-45 kg/ha of N-P (L_4). In interaction, spacing of 20 cm × 15 cm (S_1) and 20 cm × 20 cm (S_2) with 40-45 kg/ha of N-P (L_4) produced the highest seed (1419-1440 kg/ha) mainly attributed by the higher plant population and 1000-seed weight.

4. IMPROVING SALINITY TOLERANCE IN CROP PLANTS: HOW FAR AGRONOMY CAN GO?

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Salinity stress is one of the most deleterious abiotic stresses causing significant crop loss in Bangladesh. Salinity stress poses osmotic stress and ionic toxicity (Na^+ and/or Cl^-) in plants, the later one causing the major damage. Salinity tolerance in crop plants depends on the ability of plants to reduce the absorption/ uptake of these toxic ions into the plants and to compartmentalize these toxic ions into different plant organs/ tissues of less importance or into the vacuole of cell. Thus salinity tolerance of crop plants is mostly inherent character and selection of crop species/ variety is the key factor for obtaining higher crop productivity in the salinity affected area. In addition, there are some options for agronomic management practices to ameliorate the salinity stress effects in crop plants. We have been working since 2001 in collaboration with a lab in Stockholm University, Sweden and a lab in University of Bielefeld, Germany for delineating the salinity tolerance mechanisms in rice. Efforts have also been taken to ameliorate salinity stress effects in rice and other crop species through various agronomic management options such as application of gypsum, silicon etc. The results obtained so far will be presented in the conference.

5. EFFECT OF SALINITY ON PHOTOSYNTHESIS, CELL MEMBRANE STABILITY AND WATER RETENTION CAPACITY OF TWO SOYBEAN GENOTYPES DIFFERING IN SALINITY TOLERANCE

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An experiment was conducted to study the effect of salinity on photosynthesis, cell membrane stability (CMS), and water retention capacity (WRC) in leaf of two soybean (*Glycine max* L) genotypes, viz. AGS 313 (relatively salt-tolerant) and Shohag (salt-susceptible). The plants were grown in pots inside a vinyl house with 50 and 100 mM NaCl solutions and tap water as a control. Photosynthetic rate (Pn) of the two genotypes was compared at 10 and 20 days while CMS and WRC were at 15, 30, 45 and 60 days of treatment imposition (TI). Relative Pn was higher in the tolerant genotype AGS 313 than that of susceptible Shohag. At high level of salinity, Pn in AGS was reduced to only 8 % while that in Shohag to 30 % at 20 days of TI. The degree of membrane damage was higher in Shohag compared to that in AGS 313 at all growth stages studied. Salinity decreased the WRC significantly in both the soybean genotypes. However, the decreasing rate was higher in Shohag than that in AGS 313. It was concluded that the high salt tolerance of AGS 313 was associated with higher photosynthetic efficiency, CMS and greater WRC.

6. MANAGEMENT OF CROPS IN EXCESS MOISTURE ENVIRONMENT

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Many countries in the Southeast Asia including Bangladesh face severe drainage problem. Excess soil moisture caused by heavy rainfall and poor surface drainage in addition to direct flood, particularly in clay soil of most floodplain areas in Bangladesh, is a major stress affecting crop yield. There are two options for the management of crops under the excess moisture environment: the genetic and the agronomic management. Considering recent advances in the understanding of eco-physiology of excess moisture tolerance in crops, physiological approaches are becoming more feasible for genetic enhancement of crops in stressful environment. Several screening techniques have been developed to identify traits of interest, and researchers are trying to incorporate these traits to develop variety tolerant to excess moisture using conventional and biotechnological tools. However, screening of genotypes/species tolerant to excess moisture is still remained the most practical way of sustaining crop production under excess moisture environment. Besides, several options are available for the management of crops subjected to excess moisture stress. The options described are (a) additional application of nitrogen fertilizer (b) foliar application of phytohormones (c) improvement of field drainage system (d) shortening crop duration, and (e) proper crop selection and agronomic manipulation.

7. SALT TOLERANCE MECHANISMS AND DEVELOPMENT OF SALT TOLERANT VARIETY/ TECHNOLOGY OF DIFFERENT CROPS FOR COASTAL AREA OF BANGLADESH

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Iintensifying crop production in traditional rice-fallow areas of the coastal region of Bangladesh to improve livelihoods of the people of the area as well as contributing towards national food security is a major priority for the Government of Bangladesh. This area is also prone to major cyclones and tidal surge that compounds the problems associated with salinity, crop production and other facets of livelihood. To overcome these problems, crop physiology section of Agronomy Division, BARI, Gazipur conduct a series of experiments to study the salt tolerance mechanisms and developed salt tolerant variety and/or technology of different BARI mandate crops for traditional rice-fallow areas of the coastal region of Bangladesh. The experiments were conducted through Hoagland solution culture in laboratory, pot culture in venyl house, seed bed culture in stress condition and finally under natural saline condition in the coastal saline area of Nokhali, Patuakhli, Sathkhira and Dacope, Khulna. In Hoagland solution culture screening of genotypes of Barley, Mungbean, Maize, Wheat, Mustard, Soybean, Sweet gourd and Cowpea were done in laboratory. Four salt tolerant barley genotypes, 2 salt tolerant mungbean genotypes and 6 soybean variety/genotypes were selected through Hoagland solution culture, pot culture and/or seed bed culture and finally tested in coastal saline area. The salt tolerant Barley genotype BHL-15, BHL-19and Mungbean genotype BM-01, BM-08 and soybean variety Shohag, BARI soybean-5 made in Hoagland solution culture and pot culture showed consistence with that observed under field condition. The salt tolerant Barley genotypes BHL-15, BHL-19 and Mungbean genotype BM-01, BM-08 and soybean variety Shohag, BARI soybean-5 showed better adaptability in the coastal saline area. Four genotypes of sweet gourd, 11 genotypes of mustard, and 5 genotypes of cowpea were selected for further verification under pot culture and/or field trial in the coastal area. Relay cropping of BARI sarisha-11 with T.aman rice is profitable to increase production and cropping intensity in the coastal area of south-west Bangladesh in T.aman-fallow-fallow cropping pattern. Sowing of mungbean up to 3rd week of December and Sesame up to 3rd week of January in the saline area found suitable to avoid salinity as well as drought stress. Pacific-11 followed by BARI hybrid maize-5 found suitable for cultivation in the coastal cyclone prone area after harvest of T.aman rice. Tomato, cabbage and sweet gourd were found suitable for cultivation with supplemental irrigation. Rice straw followed by rice bran mulch with supplemental irrigation was suitable for pit based crops cultivation in the saline areas. BARI til-4 of sesame performed better for cultivation after T.aman rice in the saline area of Khulna and Satkhira for medium salinity level.

8. CLIMATE CHANGE AND ENVIRONMENTAL STRESS RESEARCH FOR SUSTAINABLE CROP PRODUCTION IN THE PROBLEM AREAS OF BANGLADESH

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Bangladesh is already evidencing the adverse impacts of global warming and climate change. Sustain crop production in the problem areas of Bangladesh through Environmental Stress research combating climate change is regarded as increasingly important in national issues such

as food security, poverty alleviation, land degradation and pollution control. Therefore, priority has been given on environmental stress physiology research such as: **Salinity Stress,** coastal area covers over thirty percent of the net cultivable area (2.85 m ha) of which 0.88 m ha is affected by different degrees of seasonal soil salinity. To increase production and utilize fallow land during dry season relay cropping of mustard and cowpea with T.aman rice and early sowing of mungbean, cowpea, soybean and sesame after harvest of T.aman rice showed profitable technology for saline area. Raised bed with mulch followed by drip irrigation is the most reliable technique to reduce soil salinity, save water and fertilizer and to increase production of high value horticultural crops. Mungbean line BM- 01, Barley line BHL-15, Shohag, BARI Soybean-5 of soybean found moderately salt tolerant (upto 8 dS/m) for cultivation in the saline area. **Drought stress,** drought of different intensities occur in our country, which severely effects annually about 2.3 m ha in the Kharif season and 1.2 m ha in the dry (rabi and pre-Kharif) season. During Kharif season maize, mugbean, and vegetables and in dry season mustard, wheat, potato, pulses etc crops are affected. Mungbean line BMX-90009-6, BMX-01015, BMX- 01007, wheat genotypes BAW- 923, BAW-923/4, BAW-923/BAW-824, and BAW-1138 showed drought tolerant **High Temperature Stress,** high temperature (1.2 m ha) accompanying with scanty or no rainfall accelerates the severity of drought specialty at the latter part of the Khanif-I season, which results in crop loss. On the other hand, sterility or failure in grain formation is a common feature for wheat and cole crops due to prevalence to high and low temperatures, respectively at the period of grain formation BARI Gam-20, BARI Gam-21 BARI Gam-22, BARI Gam-23, GARI Gam-24, released as moderately tolerant to high temperature. BARI Seam-3, BARI Tomato-3, BARI Tomato-4, BARI Hybrid Tomato-3, BARI Hybrid Tomato-4, BARI Piaz-2, BARI Piaz-3 are tolerant to high temperature and grown in summer season. **Water logging Stress,** flood of different types, namely flash flood, river water flood and rainwater flood or combinations of them are occurring in Bangladesh (3.5 m ha) mainly due to the occurrence of excessive rainfall. Development of waterlogging tolerant variety of maize, sesame, mungbean etc. are in preliminary stage. **Nutrient Limitation Stress (Charland),** the area under charland is estimated to be about 0.83 m ha in Bangladesh. BARI Chola-4, BARI Soybean-5, BARI Mung-6, BARI Til-4, BARI Sarisha-11, BARI Hybrid maize-7, BARI Matorshuti-2 performed better in chardand area. **Hill Agriculture,** in valley areas, most of the farmers follow T.aman-follow-fallow pattern and about 71% of the farmers harvest T. aman rice in themonth of October and 29% in November, After harvest of T. aman rice BARI Maize-5, BARI Sarisha-11, BARI Chhola-3, BARI Masur-6, BARI Matorshuti-2, BARI Jharseam-1 performed better. BARI Mung-5 followed by BARI Sarisha-11 gave maximum economic retrain and increased cropping intensity in the hill valley areas. H**aor Area,** haors form a unique ecosystem that remains inundated for 7-8 months each year. The haor basin covers about 25,000 km^2 in seven districts of north-east Bangladesh. Haors are one of the most poverty prone areas in Bangladesh, because the land is single cropped (mainly the rice) is damaged by flash floods. Coordinated research with CNRS it was found that two crops could be grown for Kanada farming. BARI Sarisha-11, BARI Sarisha-14, BARI Gam-22, BARI Gam-23, BARI Gam-24, BARI Motorshuti-2, BARI Mung-5, BARI Mung-6 performed better in haor area.

9. CLIMATE CHANGE AND HILL AGRICULTURE: RURAL LIVELIHOOD IMPROVEMENT

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The Chittagong Hill Tracts region lies in the extreme east and the southeast of Bangladesh between the latitudes of 21.11 and 23.45^0 N and longitudes of 91.42 and 92.42^0 E. The area consists of a series of anti-clinical ridges running parallel to one another and tending to the north-east direction. The climate of the region is sub-tropical monsoon. Hot and humid rainy season alternates with dry and cool winter. Soil texture varies from sandy loam to clay loam. About 51% of the population in this region is tribal (12 tribes) and the rest are Bengali. About 90% of the tribal population depends on agriculture for livelihood. The Chittagong Hill Tracts has high potential for agricultural development. Despite hilly terrain high rainfall and prolonged wet season, it remains well drained and offers an attractive scope for year-round agricultural production. After signing the peace treaty in December, 1997 some improvements have been made to the development of soil and water conservation research and agricultural technologies. Socio-economic profiles of the hill farmers indicated that the average family size was 5.01 with age 46 years. More than 60% farmers have no formal education. The average farm size was 0.55 ha but having more complex land ownership pattern. Rice based cropping pattern is predominant in the hill valley and 54% of responded farmers follow T.aman-Fallow-Fallow pattern. Research activities done in hill valley revealed that after harvest of T.aman rice BARI Sarisha-11, BARI Hybrid maize-5, BARI Chola-5, BARI Masur-4, Shatabdi, Sourav and Bijoy for wheat, BARI Hybrid maize-5 + Bus hbean and BARI Hybrid maize-5 + BABI Fallon-1 intercropping found suitable for increased production and cropping intensity. BARI Mung-5 performed better after harvest of mustard against T.aman-fallow-fallow pattern. To establish settled farming, decrease shifting cultivation and to minimize land degradation some agricultural technologies have developed and demonstrated in the hilly farm situations which will provide soil conservation, year-round production, employment and income as well as sustain eco-friendly environment for development of sustainable agricultural farming system in the region. These technologies are: pineapple based multi strata fruit production model, year-round pineapple production technology, integrated hill farming model and fruit verity development for the hill slop such as BARI Passion phall-1, BARI Multa-1, BARI Naspati-1, BARI Payara-3, BARI Lichi-3, BARI Kola-3, BARI Kola-4, BARI Jhar sheem-2, BARI Sheem-4, BARI Mistitatul-1 etc. Other component technologies such as: suitable planting time, fertilizer dose and application method, timing of irrigation for cabbage, cauliflower, broccoli, tomato, potato, maize, banana, pineapple, lemon, pear, mango, malta have been determined for hilly areas. Minimum tillage cultivation of maize, potato, cowpea, ginger and turmeric has been recommended for hill slop. Standard propagation methods of passion fruit, pear, malta, and black paper have been identified. Off season production of guava and lemon through on season flower thinning and irrigation have been found successful. Contour, Strip and hedgerow system of cropping as suitable alternatives of existing *jhum* has been developed. Technologies developed are being disseminated through training of farmers, test and block demonstration in farmer's field, establishing technology village and leaflets and booklets.

10. EFFICAY AND ACCUMULATION OF ARSENIC IN THREE WHEAT VARITIES OF BANGLADESH

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A pot experiment was conducted at net house of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from November, 2009 to February 2010 to study the effect and accumulation of arsenic in the three popular wheat varieties of Bangladesh. Three wheat variety viz. V_1= *Protiva*, V_2=*Sourav*, V_3=*Gourav* and five levels of arsenic viz. As_0=0, As_{10}=10, As_{20}=20, As_{30} =30, As_{40}=40 ppm arsenic kg^{-1} soil were used in the experiment. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Result showed that addition of arsenic significantly (*p<0.05*) reduced the growth, yield parameters and seed yield of wheat varieties. However, *Gourav* showed the potentiality against the arsenic toxicity upto 30 ppm arsenate salt in kg^{-1} soil followed by *Sourav* and *Protiva*. The maximum plant height (100 cm), tillers $hill^{-1}$(6), grain $spike^{-1}$ (47), test weight (46 g), seed yield (4.51 t ha^{-1}) but the lowest maturity days (104) was harvested in V_3As_0. Separately the lowest plant height (87.33 cm), tillers $hill^{-1}$(4.33), grain $spike^{-1}$ (36.33), test weight (41.00 g) but maximum maturity days (114) and yield reduction (5.987% compare with control) was recorded in V_1As_{40}. Arsenic concentration in plant parts increased with increasing the arsenic concentration in soil. Plant tissues were susceptible as flows roots>straw>grain and the concentrations of arsenic amounts were dependent on variety and treatment levels in polluted soils and statistically (*p<0.01*) maximum concentration of arsenic in root (3.08 µg g^{-1}), straw (0.9233µg g^{-1}) and grain (0.16 µg g^{-1}) were measured in *Protiva* variety when it was cultivated with 40 ppm arsenic kg^{-1} soil. On the contrary *Gourav* contained significantly (*p<0.01*) less amount arsenic in root (2.34 µg g^{-1}) straw (0.376 µg g^{-1}) and grain (0.04 µg g^{-1}) at the same level of arsenic contaminated soil.

11. ALLELOPATHY AS A POSSIBLE STRATEGY FOR WEED CONTROL IN MUNGBEAN

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The field experiment was conducted at the Agronomy farm of Sher-e-Bangla Agricultural University, Dhaka to investigate the performance of different weed control strategies for controlling weeds growth in mungbean plots during 2008. The experiment was carried out in split-plot design with three replications accommodating the varieties (BARI mung6 and BU mung2) in main plot and weed control strategies (no weeding, two hand weeding, herbicide application, *Acacia* extract, *Sorghum* extract, *Brassica* extract and Sunflower extract) in the sub plot. Between the varieties BARI mung6 was better performer in reducing weed density (3.73%), weed biomass (3.21%) and increasing weed control efficiency (8.38%) at 15 DAS than BU mung2. Allelopathic plant extracts inhibited weeds but less than hand weeding. Hand weeding and *Acacia* extract application significantly reduced weed density by 50.39% and 40.16% with their corresponding weed control efficiency by 54% and 50% respectively. Minimum number of weeds at 15 DAS and at 45 DAS was found in the interaction of BARI mung 6 and hand weeding (7.31 weeds/m2).

12. INFLUENCE OF HARVESTING TIME ON YIELD AND YIELD ATTRIBUTES OF MUNGBEAN

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A field experiment was carried out at the Agronomy Field of Sher-e-Bangla Agricultural University, Dhaka during the period of March 2007 to July 2007 to study the yield and yield attributes of mungbean varieties as affected by different harvesting time. The treatments were two mungbean varieties viz. BARI Mung 6 and Sona mung and five harvesting time viz. 20, 25, 30, 35 and 40 days after anthesis (DAA). The varieties behaved differently at different harvesting times. Significantly higher seed yield (1.42 t ha^{-1}) was obtained from the high yielding variety (BARI Mung 6) compared to the local variety (0.74 t ha^{-1}). Delayed harvesting (40 DAA) increased the seed yield of BARI Mung 6 but reduced the yield of Sona mung. The seed yield was 91.89% higher in the high yielding variety than the local variety. Seed yield of high yielding variety influenced only seed weight but pods/plant and seeds/pod showed higher in local variety. There was trend to increase seed yield up to harvesting 35 DAA buts pods/plant increased up to 30 DAA and seed weight 25 DAA irrespective of variety. Interaction between variety and harvesting time showed that delayed harvesting (40 DAA) gave maximum seed yield (1.66 t/ha) with BARI Mung 6 which closely followed by 35 DAA (1.63 t/ha). Local variety revealed higher seed yield (0.91 t/ha) up to 30 DAA & then declined.

13. NODULATION, GROWTH AND YIELD OF MUNGBEAN AND BLACKGRAM AS AFFECTED BY ERTILIZER MATERIALS

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An experiment was carried out at Sher-e-Bangla Agricultural University farm; Dhaka to investigate the nodulation, growth and yield of mungbean *(Vigna radiata L,*Wilckzek*.)* and blackgram *(Vigna mungo L.)* as affected by fertilizer materials during the period from March 2007 to June 2007. The trial comprised of two crops and five treatments such as C_1= mungbean and C_2= blackgram, F_1 =No fertilizer (control), F_2 = recommended chemical fertilizer, F_3 = Inoculum, F_4 = cowdung, T_5 = PK+ Inoculum. The experiment was laid out in split plot design with three replications where two crops were assigned in the main plot and five fertilizer materials in the sub-plot. Plant height, nodulation, root length, root dry weight, total dry matter production, number of branches $plant^{-1}$, pods $plant^{-1}$, number of seeds pod^{-1},1000- seeds weight, shelling percentage, seed yield, stover yield, biological yield and harvest index were compared for different treatments. Results revealed that Inoculum and PK+ Inoculum influenced significantly on most of the growth, yield parameters and yield of mungbean and blackgram. Plant height, root length, number of branches $plant^{-1}$ and pods $plant^{-1}$ were higher in blackgram than mungbean. Number of nodules $plant^{-1}$, total dry matter production, pod length, number of seeds pod^{-1} and yield were higher in mungbean than blackgram. Plant height, total dry matter production, leaf area index, number of branches $plant^{-1}$, number of seeds pod^{-1} and yield increased significantly with Inoculum and PK+ Inoculum. The higher dry matter eventually supported the plant to produce maximum number of branches and pods per plant, which resulted in maximum seed yield. A functional positive relationship was observed among number of branches per plant, pods per plant, and seeds per pod with seed yield.

14. INFLUENCE OF WEEDING ON GROWTH AND YIELD OF RAPESEED VARIETIES

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The field experiment was conducted at the Agronomy Field of Sher-e- Bangla Agricultural University (SAU), Dhaka in the Rabi season (November- February) of 2006-2007 to study the influence of variety and number of weeding on the growth and yield of rapeseed. The treatment comprised of three varieties and four levels of weeding. Different varieties were Improved Tori-7, BARI sarisha-12 and SAU sarisha-1. The weeding treatments were no weeding, one weeding at 20 DAS, two weedings at 20 and 30 DAS and three weedings at 20, 30 and 40 DAS. The experiment was laid out in a Randomized Complete Block Design (RCBD) (factorial) with three replications. The seed yield of mustard varied with varietal difference along with different weeding intervals. The growth behaviour of the three studied varieties were different and hence weeding recommendation also varied. The variety SAU sarisha-1 showed the highest yield (1.57 t ha^{-1}) response with one weeding that followed by the same variety with two weedings (1.55 t ha^{-1}) but BARI sarisha-12 responded better with two weedings. No weeding was needed for Improved Tori-7 probably due to its earlier better growth coverage.

15. EFFECT OF SOWING DEPTH AND POPULATION DENSITY ON GROWTH AND YIELD OF WHEAT

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A field experiment was conducted at the agronomy field of Sher-e-Bangla Agricultural University, Dhaka during the Rabi season from November 2006 to March 2007 with the objectives to find out the influence of sowing depth and population density on growth and yield of wheat. The experiment was carried out in split-plot design with three replications having three sowing depths viz. 2 cm, 4 cm and 6 cm in main plot and 6 population densities viz. 100 seeds m^{-2}, 200 seeds m^{-2}, 300 seeds m^{-2}, 400 seeds m^{-2}, 500 seeds m^{-2} and 600 seeds m^{-2} in the sub plot. Result showed that sowing depth had significant influence on plant height at 30 DAS, weight of dry matter at 60 DAS, number of spikes m^{-2}, length of spike, number of grains $spike^{-1}$, grain yield and straw yield. Population densities had significant effect on plant height at 30 DAS, weight of dry matter at 30 DAS, number of spikes m^{-2}, length of spike, number of grains $spike^{-1}$, grain yield, straw yield and harvest index. The result also revealed that 4 cm sowing depth showed best performance in case of grain and straw yield. The highest grain yield (3.01 t ha^{-1}) and straw yield (6.26 t ha^{-1}) was obtained from 4 cm sowing depth. Highest grain yield (3.36 t ha^{-1}) was also produced from 300 seeds m^{-2} treatment, whereas, 100 seeds m^{-2} treatment produced the lowest grain yield (2.29 t ha^{-1}). The highest straw yield was observed with 400 seeds m^{-2} and the lowest from 100 seeds m^{-2}. The highest harvest index was recorded with 100 seeds m^{-2}. Among the interaction treatments, the sowing depth of 2 cm and 300 seeds m^{-2} produced the highest grain yield of 3.72 t ha^{-1}.

16. REDUCTION OF CHEMICAL FERTILIZER USE IN MAIZE BY NUTRISMART-AN ECO-FRIENDLY FERTILIZER

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A field experiment was conducted during the Rabi 2007-08 to find out the optimum combination of chemical fertilizer and Nutrismart (an eco-friendly fertilizer) and there by reducing the use of chemical fertilizer in two Maize variety- BARI hybrid bhutta-5 and Composite variety Khaibhutta with 5 combinations of fertilizer. The treatment were F_1 (100% Recommended Chemical fertilizer), F_2 (50% Chemical fertilizer+ 50% Nutrismart), F_3 (40% Chemical fertilizer + 60% Nutrismart), F_4 (25%Chemical fertilizer + 75% Nutrismart) and F_5 (100% Nutrismart). The data revealed that the variety BARI hybrid bhutta 5 gave higher LAI, cob diameter, cob length, weight of 1000 grains, shelling percentage, biological yield (t ha^{-1}) and harvest index. On the other hand, the plant height and the rest yield contributing parameters (no.of cobs $plant^{-1}$, no. of grain rows $plant^{-1}$, no. of grains cob^{-1}) were similar in Composite variety with that of BARI hybrid bhutta 5. Both the varieties showed the similar grain, stover and biological yield (t ha^{-1}). With the reduction of chemical fertilizer, the output was reduced where F_1 gave the highest result among all the treatments but the response due to applied F_2 were quite lower than F_1. The V_1F_1 gave the highest result but the F_2 gave the more or less similar response when it was interact with the two varieties but in case of harvest index, the treatment V_1F_2 and V1F1 gave the superior result among all the interactions. The overall results indicated that in case of hybrid variety, 50 to 60% chemical fertilizer could be replaced through Nutrismart by sacrificing only 10.18 to 17.10% yield but in case of composite variety similar yield was possible by 50% chemical fertilizer + 50% Nutrismart compared to that of 100% chemical fertilizer use.

17. ALLELOPATHIC EFFECT OF *BRASSICA* BIOMASS ON WEED CONTROL OF WHEAT

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Two experiments were conducted to study the allelopathic effects of *Brassica* spp. to control weeds in wheat. Significantly the highest weed dry matter (1.72 g/m^2) was revealed in *Brassica juncea* plots at 30 DAS but in *Brassica napus* field (1.44 g/m^2) at 50 DAS. The lowest weed dry matter (0.89 g/m^2) was recorded in total incorporation of *Brassica* biomass to the soil at 30 DAS but 50% incorporation and 50% spreading at 50 DAS. The lowest weed population (15.33/m^2) was revealed in spreading between lines that similar to complete incorporation and 50% spreading and 50% incorporation at 30 DAS. The *Brassica* biomass spreading above ground (B_2), mixed with soil (B_3) and 50% spreading + 50% mixed with soil (B_5) resulted positively compared to other ways of biomass incorporation. The highest (3.83 t/ha) grain yield of wheat was given by *Brassica juncea* when spreaded on the above ground soil (S_2B_2). The second year study showed the highest weed dry matter (24.94 gm^{-2} at 50 DAS in previous

fallow crop field. Weed population in wheat field was significantly reduced by the increasing of *Brassica* biomass concentration. Incorporation of *Brassica* biomass reduced weed population as well as weed dry matter in wheat field compared to that of no *Brassica* biomass incorporation. The wheat yield was affected by the previous crop condition where previous Brassica crop gave the higher wheat yield (2.69 t/ha). Application of 1.0 kg m^{-2} *Brassica* biomass showed the highest wheat yield (2.72 ha^{-1}) that followed by 0.5 kg m^{-2} *Brassica* biomass (2.54 t ha^{-1}) and no *Brassica* biomass (2.37 t ha^{-1}). The highest wheat yield (2.86 t/ha) was given by the previous *Brassica* crop field that treated with 35 days old *Brassica* plants @ 1.0 kg m^{-2} *Brassica* biomass.

18. CULTIVATION OF RICE USING DIFFERENT PLANTING TECHNIQUES

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Four experiments were conducted to compare the performance of hybrid and inbred variety under different cultivation methods along with the performance of clonal tillers. The rice varieties included in these studies were Sonarbangla -1 as a hybrid variety and BR11 (Mukta) in first year Aman season, BRRI dhan32 for the second year Aman season and BRRI dhan29 in Boro season. Three planting materials viz. sprouted seeds, nursery seedlings and clonal tillers were used in first experiment along with two planting methods viz. line and haphazard planting. Five cultivation methods viz. sprouted seeds broadcasted, sprouted seeds in line, nursery seedlings, SRI and clonal tillers were included in the second experiment. Five tiller separation days viz. tiller separation at 20, 25, 30, 35 and 40 days after transplantation were included in the third experiment and five different ages of clonal tillers viz. 20, 25, 30, 35 and 40 days were tested in the fourth experiment. Results showed that hybrid variety performed better in all the experiments compared to inbred variety. Clonal tillers performed better in Aman season but nursery seedlings in Boro season. Planting in line showed better performance with highest grain yield (4.81 t ha^{-1}) than haphazard method (4.32 t ha^{-1}). The combined effect of planting materials, varieties and planting method resulted in the highest grain yield from clonal tillers of hybrid variety with line sowing method in the first experiment. Nursery seedlings of the inbred variety resulted the highest grain yield (8.88 t ha^{-1}) and sprouted seeds broadcast of the inbred variety gave the lowest grain yield (6.35 t ha^{-1}) in second experiment. Earlier tiller separation (20-25 DAT) resulted higher grain yield in hybrid variety but no such variations was observed in inbred variety.

19. RELAY INTERCROPPING POTATO WITH SUGARCANE FOR ADAPTATION WITH CLIMATE CHANGES IN RIVER BASIN (*CHAR*) AREAS

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The river basin island, known as "*Char*", for about last 20-35 years. The chars are generally formed during rising of the river bed through sedimentation carried by upstream flows. Cropping intensity of *Char* areas is less than national average as there is only one cropping season for cultivation in the chars. Transplanted aman rice is the main crop of that area. After

harvest of T. aman rice, most of the lands remain fallow or underutilized. So, the livelihood status of *char* land people is miserable and as such they are underprivileged.

Padakhep Manabik Unnayan Kendra has been working on disaster risk reduction issues since 2005 with Oxfam-GB fund for promoting *char* friendly agricultural technologies that can adopt with climate changes. It disseminated sugarcane (cultivar ISD-37) cultivation in Kurigram district, which can sustain in flood and drought condition, even can grow satisfactorily in unstructured soil in *Char* land. It was observed that within a year, the *char* farmers could improve their livelihood and income level by growing relay crop potato with sugarcane. The results of these studies are very interesting and encouraging because it can be easily extrapolated in other parts of the country and abroad for adoption.

20. MINIMUM TILLAGE SEEDING TECHNIQUE FOR SAFE ENVIRONMENT AND SUSTAINABLE RICE-WHEAT CROPPING SYSTEM IN BANGLADESH

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Minimum tillage technique accomplishes seeding operation directly through crop residue by power tiller operated seeder. It works as shallow tilling, seeding in line, fertilizing, seed covering and land leveling simultaneously in one operation maintaining the standard agronomic practices. This seeding technique was demonstrated in different locations of northern part of Bangladesh for establishing crop in rice-wheat system. Wheat, maize, lentil and chickpea planted after rice harvest and mungbean, sesame, jute planted after wheat harvest. This tillage technique helps growers minimizing turnaround time 8-12 days between the two crops utilizing the residual soil moisture. This seeder maintains uniform seeding depth; uniform seed distribution and better seed soil contact which transfer soil moisture to seeds quickly for enhance better plant establishment and yield. Application of irrigation water was faster than conventional method. It saved irrigation water 11.6% in wheat and 66% in rice cultivation. In dry surface condition of minimum tillage rice field, no crack formation observe on the surface but in conventional puddling plots, soil surface cracked easily. Wheat yield was 25% higher over conventional seeding method. It is environment friendly, minimum disturbance soil and save diesel fuel 94 lit./ha/yr over conventional practice. Carbon dioxide (CO_2) emission into atmosphere by minimum tillage is 44% less than conventional tillage method which helps to minimize greenhouse effect. Effective field capacity and seeding cost of the seeder was 0.15ha/hr and Tk.1585.0/ha, respectively which was 67% less than conventional method. Breakeven point of the seeder was 4.1ha which indicate the critical margin of seeder annual use for no loss no profit point.

21. GRAIN GROWTH AND GROWTH ANALYSIS OF BARI MUNG 5 AND BARI MUNG 6

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A field experiment was conducted at the Regional Agricultural Research Station, Jessore to evaluate the grain growth pattern of BARI Mung 5 and BARI Mung 6 during kharif season of 2010. Flowers of BARI mung 5 and BARI mung 6 were tagged and data on pod development was recorded from 3 to 21 after anthesis (DAA). The maximum pod length (10.18 cm), fresh weight of pod (1.96 g), seed coat (1.15 g) and seed (1.00 g) were recorded from 17, 13, 9, and 13 DAA, respectively. But maximum dry weight of pod (0.60 g), seed coat (0.32 g) and seed (0.39 g) were obtained from 11, 11 and 13 DAA, respectively. Germination percent (100%) reached maximum from 17 DAA. Maximum crop growth rate (16.13 g/m^2/day) was recorded at 36-43 days after emergence. But relative growth rate (0.212 g/g/day) and net assimilation rate (26.05 g/m^2/day) were maximum at 15-22 DAE. The maximum root length (4.35 cm) was attained at 19 DAA which was statistically similar to that of 17 DAA (4.25 cm) and the shoot length maximum (8.83 cm) at 19 DAA. Highest vigour index (883000) was also recorded at 19 DAA.

22. INTER-CROPPING GINGER, TURMERIC, ONION, GARLIC AND CORIANDER WITH POINTED GOURD

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An experiment was conducted at the RARS, Jessore during 2008-09 to find out suitable spices crop inter-crop viz. turmeric, ginger, onion, garlic and coriander with pointed gourd. The edible fruit yield of pointed gourd did not varied significantly due to cultivation of spices crops with pointed gourd. Among the five spices crops, pointed gourd + garlic + turmeric cultivation was more economic. The maximum pointed gourd equivalent yield (59.54 t/ha), gross return (834960 Tk/ha), net return (563953 Tk/ha), benefit cost ratio (3.08).

23. IMPROVING DROUGHT TOLERANCE IN MAIZE BY EXOGENOUS APPLICATION OF PHYTOHORMONE

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Maize is a dependable cash crop to meet the increase demand of the poultry, fisheries and livestock sectors in Bangladesh. Drought is considered the major environmental stress limiting maize production. For improving drought tolerance of maize, two phytohormones: gibberellic acid (GA_3) and cytokinin (CK) at different concentrations (50, 100 and 150 mgL^{-1}) were applied as a foliar spray to 6-week old maize plants experienced water stress. The growth and yield performance of maize for these sprays were compared with water deficit and well watered control plants. Both GA_3 and CK improved growth attributes including plant height, root and total plant dry weight compared to water deficit condition. Such effects were found to be pronounced when concentration of the hormones increased. However, GA_3 and CK performed differently in yield and yield contributing characters. Grain weight cob^{-1} $plant^{-1}$ and number of seeds cob^{-1} $plant^{-1}$ decreased as the concentration of GA_3 increased, but they increased with the

increasing CK concentration. Cytokinin @150 mgL^{-1} increased grain weight by 76% compared to water deficit condition, which was 82% relative to control plants. The exogenous application of GA_3 and CK improved drought tolerance of maize plants by maintaining higher biomass production and its greater contribution to grain yield.

24. MUSTARD–BORO RICE MIXED CROPPING, A POTENTIAL TECHNOLOGY TO BOOST UP MUSTARD PRODUCTION

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Due to continuous increasing of Boro rice area, coupled with adverse climatic condition and along with delayed T-aman harvesting, mustard production decreasing day by day. To avoid this farmers practices Mustard with Boro rice cultivation at a time as mixed cropping system in low lying areas of greater Comilla. The practices are gradually increasing and farmers uses different ratios of mustard seed with boro rice and getting different results. To know the appropriate seeding ratio an experiment was conducted in the farmer's field of Hajiganj and Motlab of Chandpur, Daudkandi Upazilla of Comilla (2008-2009 & 2009-2010) with different seeding ratio of mustard (100%, 75% and 50%) with sole rice. Rice variety BRRI dhan -29 @ 60 kg/ha with BARI Sharisa -14 @ 7 kg/ha was used in this study. Result revealed that 100 % mustard (1.58 t/ha) and 100% rice yield (4.74 t/ha) can achieved without reducing the rice yield. So Mustard–Boro rice mixed cropping can be potential technology in the low lying areas where only mustard cultivation cant possible due to environmental adverse condition.

25. SCREENING OF SESAME GENOTYPES TO WATERLOGGING TOLERANCE

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Screening of sesame genotypes to water logging tolerance was done at the research field of Agronomy Division, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur during the period from March to June 2010. Fifty sesame genotypes were tested against three waterlogged condition such as control (no water logging), water logging at vegetative stage and water logging at flowering stage. The results revealed that 100% plant mortality was found in all the genotypes when waterlogged at flowering stage. When waterlogged imposed at vegetative stage, about 36.2-100% mortality was found in the sesame genotypes. On the basis of plant mortality (%), seven sesame genotypes such as BD-6980 (36.2%), BD-6994 (52.38%), BD-6960 (52.94%), BD-6992 (53.38%), BD-7012 (54.29%), BD-6984 (56.67%) and BD-6985 (60%) were primarily selected for further evaluation to water logging stress tolerance. Although dry matter accumulation in different plant parts i.e., stem+leaf and capsule, number of capsules/plant and seed weight/plant were also found higher in BD-6980, BD-6984, BD-6985, BD-6992, BD-6994 and BD-7012 under water logging at vegetative stage compared to control but seed yield/m^2 decreased due to water logging in all the genotypes. On the basis of water logging stress tolerance indices including stress susceptibility index (SSI), stress

tolerance index (STI) and yield stability index (YSI), the genotypes BD-6980, BD-6985, BD-6992 and BD-7012 genotypes were selected as water logging tolerant at vegetative stage.

26. SCREENING OF WHEAT GENOTYPES FOR DROUGHT TOLERANCE AT VEGETATIVE STAGE

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Screening of wheat genotypes for drought tolerance was done at the research field of Agronomy Division, BARI, Joydebpur, Gazipur during the rabi season of 2009-10. Thirty (30) wheat genotypes were evaluated against drought at vegetative stage (stress was imposed from CRI stage to before anthesis by withholding irrigation) with control (no drought). Exposure of plants to drought led to noticeable reduction in yield and all the yield contributing characters such as plant height (1-13 %), number of spikes per plant (10-48 %), TDM (16-45 %), number of seeds per spike (7-43 %), 100- seed weight (49-69%) and seed yield (15-65 %). Under drought stress condition, BCN, BAW- 923(C7), KAN (C9) and BAW- 1138 produced higher seed yield than other genotypes, which gave above 80% seed yield compared to control. These genotypes showed higher values of all other yield-contributing characters under drought stress. Based on the yield of genotypes under control (YP) and drought stress (YS) conditions, three quantitative drought tolerance indices including yield stability index (YSI), drought susceptibility index (DSI) and drought tolerance index (DTI) used to evaluate drought responses of these genotypes. According to drought tolerance index, Shatabdi, BCN, KAN (C9), BAW- 923/4, BAW- 923/BAW- 824, Garuda and Oasis (RC5 Jo) showed higher values (DTI >0.8) though Shatabdi, Oasis (RC5 Jo) and Garuda were discarded from the selection because they produced very lower yield in stress condition and DTI was able to identify cultivars producing high yield in both conditions. The genotypes BCN, BAW- 923 (C7), KAN (C9) and BAW -1138 showed higher values in yield stability index (YSI >.8) and lower values in drought susceptibility index (DSI <0.6). On the basis of DTI, DSI and YSI, the genotypes BCN, BAW 923- (C7), KAN (C9), BAW -923/4, BAW- 923/BAW- 824 and BAW- 1138 were selected as drought tolerant at vegetative stage.

27. EXPLOITATION OF NITROGEN BY PARTHENIUM WEED AND ITS INHIBITORY EFFECTS ON THE GROWTH OF RICE

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An investigation was made in pot culture to assess the nitrogen exploitation capacity of Parthenium weed (*Parthenium hysterophorus* L.) and its effects on the seedling growth of rice under different doses of nitrogen. Four levels of nitrogen viz., 0, 20, 40 and 60 kg N/ha were applied in the experimental pots in the form of urea. Three seedlings of rice (cv. BRRI dhan29) along with a Parthenium weed were raised per pot. Rice and Parthenium seedlings were also raised alone (monoculture) in separate pots. Total nitrogen content in plants, post harvest soil nitrogen, shoot length, number of branches or tillers/pot, root length of both rice and

Parthenium were recorded at 70 days of seeds placement. Parthenium had higher rate of nitrogen uptake capacity than rice plants. Nitrogen contents in Parthenium in presence of rice were 0.73%, 0.65%, 0.60% and 0.52% at 60, 40, 20 and 0 kg N/ha, respectively. In case of rice it was 0.64%, 0.56%, 0.52% and 0.45% with the respective doses of nitrogen. The percent reduction in nitrogen content in rice plants due to Parthenium competition were 11.85, 13.12, 12.85 and 14.75 at 60, 40, 20 and 0 kg N/ha, respectively. Post harvest soil nitrogen was always lower in case of Parthenium grown soil than rice grown soil. Post harvest soil nitrogen (%N) under monoculture of Parthenium were 0.18, 0.18, 0.17 and 0.17 at 60, 40, 20 and 0 kg N/ha, respectively, and in case of rice it was 0.205, 0.203, 0.194 and 0.189 with the respective doses of nitrogen. The percent reduction of post harvest soil nitrogen by rice plants were 7.66, 8.56, 12.61 and 14.86. The per cent reduction of post harvest soil nitrogen by Parthenium were 18.47, 20.27, 21.62 and 25.23 at 60, 40, 20 and 0 kg N/ha, respectively. Percent reduction in shoot length of rice plants were 23.64, 37.89, 28.21 and 35.03, in numbers of tillers/pot were 64.91, 64.77, 57.01 and 51.06, in root length were 34.08, 32.21, 37.82 and 27.20, in seedling dry weight were 53.64, 46.85, 54.83 and 58.06 at 60, 40, 20 and 0 kg N/ha, respectively, due to inhibitory effects of the Parthenium weed. Percent reduction of shoot length of Parthenium plants were 10.22, 12.55, 15.32 and 28.99, in numbers of branch/plant were 37.13, 34.55, 25.00 and 8.33, in root length were 19.01, 17.98, 14.16 and 11.57, in seedling dry weight were 26.74, 27.04, 35.01 and 35.85 at 60, 40, 20 and 0 kg N/ha, respectively, due to competition from rice. Rice was mostly affected by Parthenium weed and the growth of rice was reduced by about 50% when grown with the weed at the rate of one plant per three rice plants.

28. ALLELOPATHIC EFFECTS OF PARTHENIUM WEED DEBRIS IN SOIL ON THE EMERGENCE AND DEVELOPMENT OF FIELD CROPS

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An investigation was made to assess the allelopathic effects of parthenium weed debris (*Parthenium hysterophorus* L.) in soil on the emergence and seedling development of three field crops namely rice, mungbean and soybean in pot culture. Parthenium fresh leaves and plants were air-dried for one week in the greenhouse. The air-dried plant samples were then cut into smaller pieces (0.5-1 cm) and mixed with pot soil. Four concentrations of weed debris (e.g. 0, 0.25, 0.5 and 1.0g dry weight per 100g soil) were included. Twenty five non-dormant seeds of three field crops (i.e. Rice, Mungbean and Soybean) were put in the soil of the pots. The pots were watered regularly with equal amount of tap water. The number of emerged seeds was counted daily up to 12 days of seed placement. Plant height, leaf numbers and leaf area of the crops were measured after 30 days of seed placement. The dry weight of randomly selected 10 seedlings was recorded after being dried at 72^0C in an electric oven for seven days. Percent reduction due to different concentration of parthenium weed debris was estimated and the average percent inhibition (API) was calculated by dividing sum total of percent reduction in seed emergence, plant height, leaf number, leaf area and seedling dry weight by five. The weed debris at different concentrations of Parthenium reduced the seed emergence, plant height, leaf numbers; leaf area and seedling dry weight of the field crops. Seed emergence was reduced by 25.40%, 15.39%, 22.19%, plant height was reduced by 20.98%, 26.01%, 18.20%, leaf number

was reduced by 20.06%, 12.90%, 9.36%, leaf area was reduced by 33.85%, 49.17%, 44.5% and dry weight was reduced by 22.78%, 34.70% and 33.50% in rice, mungbean and soybean, respectively. Among the field crops mungbean was mostly affected followed by soybean and rice. When the effects of weed debris on all the crops parameters were considered, leaf area was mostly affected than other parameters. The ranking of crops on the basis of API was- Mungbean (27.64%) > Soybean (25.55) >Rice (24.81). The inhibitory effects on field crops were positively related to the concentration of parthenium weed debris in soil.

29. FERTILIZER MANAGEMENT FOR WHEAT-MUNGBEAN-RICE CROPPING PATTERN IN ZERO TILLAGE CONDITION

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Growing crops in zero tillage is one of the best technologies in resource conservation in agriculture since less amount of CO_2 is emitted and less soil erosion occurs in zero tillage compared to conventional. Study was carried out in Wheat Research Centre, Dinajpur during 2005-2008 to evaluate Wheat-Mungbean-Rice cropping pattern in zero tillage against in conventional, and to find out the suitable fertilizer management procedure in zero tillage condition. Wheat and mungbean could be grown in zero tillage without yield loss. Higher amount of mungbean residue was obtained from zero than from conventional tillage. Grain yield of rice was higher in conventional than in zero tillage in the first year, and then comparable yield was obtained from zero tillage. In zero tillage for wheat, recommended dose of fertilizers (except N and P) might be applied before sowing or after first irrigation. DAP or TSP should be used with the zero till machine during sowing. Total amount of N or calculated rest amount of N (in case of DAP) might be applied after first irrigation. For mungbean, a pre-sowing irrigation should be applied and all the recommended fertilizers should be applied after the irrigation. For rice, recommended dose of fertilizers (except N) might be applied 0-25 days after sowing. Nitrogen might be applied according to leaf colour chart or in 3 equal installments *viz.*, 15-25, 35-45 and 50-75 days after sowing depending on requirement.

30. CRITICAL TEMPERATURES AND THEIR PROBABILITIES ON THE DIFFERENT IMPORTANT GROWTH STAGES OF RICE

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A Boro crop might be affected by low temperature at the beginning and at the reproductive phases of the crop. More so, global warming effect might have an impact on crop growing season and the crop. To get rid of this problem we should have better understanding of temperature impact with respect to growth stages of the crop. Therefore, the objective of this study is to find out the critical temperature (minimum and maximum) and their probability of occurrence on certain sensitive growth stages of Boro. The crop data were used from a study at BRRI, Gazipur. We considered only the reproductive phase of crop. The critical temperature should be carefully considered based on the critical yield level. However, minimum temperature of 12-13°C during API and Booting and the corresponding maximum temperature

28-29°C could be considered as critical temperature as these levels reduced 50% of the original yield level. The probability of these critical temperatures reduced with the advancement of reproductive phase to the warmer part of the Boro.

31. EFFECT OF GREEN MANURING CROPS IN DIFFERENT CROPPING PATTERNS ON RICE PRODUCTIVITY UNDER RAINFED ECOSYSTEM

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Experiments were conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh to see the effect of green manuring crops in different cropping patterns on productivity of rice under rainfed ecosystem during July 1996 to December 1999. The experiment consisted of six cropping patterns (with five designed patterns) due to inclusion of green manuring crops in farmers' predominant practiced Fallow-Direct seeded Aus rice-T.aman rice (R_1) pattern under rainfed ecosystem. Five designed patterns were Fallow-Direct seeded Aus rice + Mungbean-T.aman rice (R_2), Direct seeded Aus rice-T.aman rice + Grasspea (R_3), Direct seeded Aus rice-T.aman rice + Blackgram (R_4), Direct seeded Aus rice + Mungbean-T.aman rice + Grasspea (R_5), and Direct seeded Aus rice + Mungbean-T.aman rice + Blackgram (R_6). It was observed that yield and yield contributing characters of rice were significantly affected by green manuring crops. Fallow-Direct seeded Aus rice-T.aman rice pattern (R_1) showed the lowest productivity. Rice productivity increased up to 11-24 per cent due to inclusion of green manuring crops and their incorporation into soils. Rice productivity was obtained the highest due to growing two green manuring crops within a pattern.

32. FOOD SECURITY AND ECOLOGICAL FOOTPRINT OF COASTAL ZONE OF BANGLADESH FOR SUSTAINABLE DEVELOPMENT

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This paper presents the present status of food security and ecological footprint, an indicator of environmental sustainability of the coastal zones of Bangladesh. A quantitative method for computation of food security in grain equivalent based on economic returns (price) is developed and a method of measuring sustainable development in terms of ecological footprint developed by Wackernagel is used to estimate the environmental sustainability.
Overall status of food security at upazila levels is good for all the upazilas except Shoronkhola, Shyamnager and Morrelgonj and the best is the Kalapara upazila. But the status of food security at household levels is poor. Environmental status in the coastal zones is poor for all the upazilas except Kalapara and Galachipa. The worst is in the Mongla upazila. Environmental status has degraded mainly due to shrimp culture.
A system dynamics model of integrated management of coastal zone for food security has been developed. This model predicts that if shrimp aquaculture industry continues to boom from the present status to super intensive shrimp aquaculture, a collapse of the shrimp aquaculture

industry will ultimately occur turning shrimp aquaculture land neither suitable for shrimp culture nor crop production. The control of growth of the shrimp production intensity stabilizes the system at least in the short run. The control of population and the growth of the shrimp production intensity should be considered for stabilization of the system in the long run. The sustainable development of the coastal zone of Bangladesh in the long run without control of both the growth of shrimp production intensity and population will remain mere dream.

33. GROWTH AND YIELD RESPONSES OF MUNGBEAN GENOTYPES UNDER FLOODING, WET PUDDLING AND SATURATED SOIL CULTURE

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Saturated or soil flooding conditions due to excessive rainfall and inadequate drainage are environmental stresses in upland crops after rice. These stresses as well as wet puddling situations for rice greatly reduced production of mungbean, particularly in the southern Bangladesh. The study examined the three mungbean genotypes viz. VC3950-88, VC6173A and BARImug5 differing in growth and yield responses to soil flooding, wet puddling and saturated soil culture. Wet puddling significantly reduced field emergence and vigor index of mungbean. Plant height was adversely affected by different moisture regimes, but recovery was better in flooding situation. Chlorophyll content also reduced significantly and recovered almost wholly. Damaging of roots or impairing root growth occurred in differential water regimes. However, subsequent recovery of total plant biomass was found better in flooding situation due to quick formation of adventitious roots. Plants grown under saturated soil culture also recovered to some extent presumably for producing greater amount of root nodules. Accordingly, seed yield reduced less relative to control in flooding condition followed by saturated soil culture. Wet puddling situation was worst showing depressed growth and reduced seed yield. Among the genotypes, VC6173A was best adapted under three moisture regimes giving the highest seed yield by producing higher amount of pods, greater seed size and longer pod.

34. PARTHENIUM INFESTATION IN BANGLADESH: IS IT RISKY IN THE CHANGED CLIMATE IN FUTURE?

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Parthenium weed (*Parthenium hysterophorus* L.) is an environment pollutant and invasive weed in Bangladesh. It contributes detrimental allelopathic effects to and competes with highland crops including rice; maize, wheat and barley. The weed causes eczema, skin rushes in human and livestock body when it comes in contact for a considerable period of time. Intake of parthenium pollen may cause asthma, bronchitis and other respiratory problems. Allergic swollen mouth of cattle, swelling of udder of cows and ulceration in the stomach may also occur if the weed is consumed by the livestock. The milk of cows become unsuitable for drinking and flesh of bullocks become taint when they consume parthenium weed. In a

preliminary survey, it has been marked that 11 districts of the country have already been infested with the weed. The badly infested districts are Jessore, Faridpur, Norail, Magura, Rajshahi, Natore and Manikgonj. The districts of less infestation are Sirajgonj, Dhaka and Mymensingh. A new area in Patuakhali district, Barisal-Patuakhali highway has recently been identified as parthenium infested. No doubts, many more area will be included in the list if detailed survey can be done throughout the country. The atmospheric temperature might increase in future due to the increased greenhouse gas effects and parthenium being the owner of both C3 and C4 plant characteristics will be favoured more by the expected increased temperature. Therefore, Bangladesh might be at high risk of parthenium pollution.

35. EFFICACY OF NITROGEN AND PLANT SPACING ON GROWTH AND YIELD OF BORO RICE -BRRI DHAN 29

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An experiment was conducted at Agricultural farm of Sher-e-Bangla Agricultural University (SAU), Dhaka, during December 2007 to May 2008, in Boro season to study the efficacy of nitrogen and plant spacing on growth and yield of boro rice (BRRI Dhan 29). There were three doses of nitrogen (150, 200 and 250 kg ha^{-1}) and four plant spacings (25 cm × 10 cm, 25 cm × 15 cm and 25 cm × 20 cm and 25 cm × 25 cm respectively). The experiment was laid out in a split-plot design with three replications. Nitrogen rates were placed in main plots and spacing in unit plots (sub-plot). The variety used in the experiment was BRRI Dhan 29. It was observed that higher rate of nitrogen application and with higher plant spacing contributed highest plant height, number of tillers $hill^{-1}$ and dry weight $hill^{-1}$ but closer spacing showed maximum leaf area index. In case of panicle length, 1000 grain weight, total grain yield, biological yield and harvest index were not responsive to higher rate of nitrogen application and maximum plant spacing but with the application of 200 kg N $ha^{-1}$with 25 cm × 15 cm plant spacing gave the highest grain yield (7.58 t ha^{-1}), biological yield, 1000-grain weight and harvest index.

36. MANAGING COASTAL SOILS FOR INCREASED FOOD PRODUCTION UNDER THE CHANGING ENVIRONMENT

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Bangladesh has to increase food production for its ever increasing population from a shrinking landmass. Two options available for increased food production are (a) increase crop yield per unit land through crop improvement and improved management, and (b) bringing the unfavorable ecosystems under food production. Due attention was not given to exploit the productive potential of the coastal region of the country. Recently the issue has been put high on the agenda by the Government. As such several departments, development organizations and donor funded projects have been working in the line. The author pioneered in characterization of the coastal ecosystems and exploited the production potential of the costal region. Coastal region is characterized by tidal flooding both in the saline and non-saline

phases. Dynamics of soil and water salinity has been impacted by the climatic variability and thus crop production in the region needs special adjustment and management of soil and crop. This paper discussed various soil and crop managements that help increasing food production in the changing environment of the coastal region in a sustainable way.

37. WEED CONTROL AND YIELD OF WHEAT AS AFFECTED BY INCORPORATION METHODS OF Brassica BIOMASS

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The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from October 2007 to February 2008 to study the weed control and yield of wheat as affected by incorporation methods of *Brassica* biomass. The experiment had two factors. Factor A: *Brassica* Species (3 levels) viz. S_1: *Brassica campestris*, S_2: *Brassica juncea* and S_3: *Brassica napus*; Factor B: Incorporation methods *Brassica* biomass (5 levels): B_0: Control (no biomass application); B_1: Spreading above the ground; B_2: Mixed with soil; B_3: Spreading in line and B_4: 50% spreading + 50% mixed with soil. At 30 DAS, the maximum numbers of weeds (25.53 m^{-2}) were found in the plot treated with *Brassica juncea* which was 44.81% higher than the least number of weed population (17.67 m^{-2}) from *Brassica campestris*. At 50 DAS, *Brassica juncea* also showed the highest weed population (20.20 m^{-2}). *Brassica campestris* had the best effect on weed control showing the least number of weed population (14.07 m^{-2}). At 30 DAS, the lowest weed population (15.33 m^{-2}) was seen by B_3 while the highest (26.89 m^{-2}) was found in the B_2. At 50 DAS, the highest (20.89 m^{-2}) weed population was found by B_2 whereas, B_4 showed the lowest (13.11 m^{-2}) population. S_1B_2 showed the lowest (8.67m^{-2}) at 50 DAS which was significantly lower than those of S_2B_0 (37.33m^{-2}) and S_3B_2 (40.00m^{-2}) at 30 and 50 DAS respectively. Among the *Brassica* species S_2 produced the highest grain yield (3.52 t ha^{-1}) while the lowest (3.32 t ha^{-1}) was obtained from S_3. The highest grain yield (3.54 t ha^{-1}) was recorded from B_0 while the lowest (3.32 t ha^{-1}) was recorded from B_2. The S_2B_1 had the highest grain yield (3.83 t ha^{-1}) whereas the lowest (3.06 t ha^{-1}) was recorded from S_3B_1.

38. INFLUENCE OF NITROGEN AND PLANT POPULATION ON THE GROWTH AND YIELD OF SESAME

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A field experiment was conducted during March to July, 2009 to assess the influence of four nitrogen levels *viz.*, 0, 30, 45 and 60 kg ha^{-1} and plant population density *viz.*166666, 222222, 333333 and 666666 plants ha^{-1} on the growth and yield attributes of sesame. The experiment was conducted as a Randomized Complete Block Design with three replications. Results showed that different levels of N fertilizer and plant population had significant effects on growth, yield and yield attributes of sesame. The addition of N levels resulted in the increasing of growth, yield and yield attributes of sesame and the highest plant height (115.50 cm), branch $plant^{-1}$ (4.57), capsule $branch^{-1}$ (17.36), total capsule $plant^{-1}$ (80.32), numbers of effective

capsule plant^{-1} (76.47), capsule length (2.38 cm), seed capsule^{-1} (70.13), filled seed capsule^{-1} (68.31), 1000 seeds weight (3.46 g), seed yield (1.50 t ha^{-1}) and harvest index (24.45%) were obtained from 60 kg N ha^{-1}. On the other hand, increasing of plant population resulted decreases in growth, yield and yield attributes of sesame where plant height, unfilled seed capsule^{-1}, seed yield, stover yield and harvest index had no significant effect. The highest seed yield of sesame plant (1.50 t ha^{-1}), stover yield (4.64 t ha^{-1}) and harvest index (24.45%) were found from 666666 plants ha^{-1} plant population. The combined effect of nitrogen levels and plant population had a significant difference among the plant parameters of sesame. The highest branches plant^{-1} (5.12), capsule branch^{-1} (19.07), total capsule plant^{-1} (97.55), numbers of effective capsule plant^{-1} (93.75), capsule length (2.79 cm), seed capsule^{-1} (84.63), filled seed capsule^{-1} (82.88), 1000 seeds weight (3.65 g) was found from 166666 plants ha^{-1} combination with 60 kg N ha^{-1} but highest plant height (120.00 cm), seed yield (1.76 t ha^{-1}), stover yield (5.07 t ha^{-1}) and harvest index (25.73%) were recorded from 666666 plants ha^{-1} combination with 60 kg N ha^{-1}.

39. THE INFLUENCE OF DROUGHT STRESS ON GROWTH, YIELD AND YIELD COMPONENTS OF SELECTED FRENCH BEAN GENOTYPES

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A pot experiment was carried out in poly-tunnel at the Bangabandhu Sheikh Mujibur Rahman Agricultural University, Bangladesh during 2006-07 to investigate the influence of water stress on growth, yield and yield components of selected French bean genotypes. Seven genotypes were evaluated for tolerance to terminal water deficit at seedling stage. Water deficit significantly reduced growth, yield and yield components of the French bean genotypes. The genotypes BB24 and BB43 showed tolerance to water stress recorded minimum reduction of seed yield, higher relative yield, and accumulated and partitioned more assimilates to the seed than the drought-susceptible genotypes BB04 and BARI bushbean-2. Also the drought-tolerant genotypes had less reduction of pods plant^{-1} and seed size.

40. SOIL FLOODING TOLERANCE IN MUNBEAN UNDER FIELD CONDITIONS

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Three-week old seedlings of six mungbean genotypes were evaluated for flooding tolerance. All the growth and yield attributes decreased significantly during flooding and recovery period. However, genotypes differed significantly in recovering the depressed characters. Flooding reduced plant height, chlorophyll index, number of leaves and dry matter accumulation significantly in most of the genotypes. Roots were severely injured during flooding showing 23-59% reduction in dry weight. However, the genotype VC3960-88 recovered to a great

extent by producing numerous adventitious roots. Flooding also resulted in leaf chlorosis, defoliation and cessation of growth. In general, net assimilation rate of flooded plants reduced compared to control plants, although some genotypes showed better recovery. Soil flooding tolerance based on the ratio of the relative growth rate of total plants under flooded and non-flooded control indicated that VC3960-88 had greater degree of tolerance followed by BARImug4. The genotypes those showed more tolerance to flooding gave better seed yield. Rapid recovery of root systems and its contribution to shoot growth had strong correlation with the grain yield production of mungbean. In this study, the variation in flooding tolerance of the tested genotypes was existed, and hence, similar study under different growing seasons and locations employing the genotypes is needed for affirmation.

41. NUTRIENT USE AND CARBON SEQUESTRATION EFFICIENCIES OF DIFFERENT ORGANIC WASTES IN RICE

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Effect of household waste (HW), chicken manure (CM) and cow dung (CD) on nutrient use and carbon sequestration efficiencies and to improve soil fertility were assessed using 11 treatments in a randomized complete block design. Except the control and recommended doses of N, P and K, other nine treatments were composed of organic and inorganic nutrients where each of HW, CM and CD were applied at the rate of 2.0, 3.0 and 4.0 kg m^{-2}. Application of household waste 4 kg m^{-2} produced the maximum grain yield of rice. Nutrient uptake and use efficiency were enhanced with the application of wastes. The higher agronomic, physiological and recovery efficiencies of N, P and K were attributed better running of waste and crop management practices. Incorporation of wastes increased OM content in soils up to 193% from the control. The maximum OC sequestration 2.6 Mg ha^{-1} was observed when wastes were applied at the rate of 4 kg m^{-2}. The trend of OC sequestration were in the order of CD>HW>CM. The residual value of pH, OM, P and K indicated the fertility enhancement of soils with the application of wastes. Higher application of wastes decreased the soil bulk density.

42. DOUBLE TRANSPLANTING IN BORO FOR ENHANCING SYSTEM PRODUCTIVITY OF T. AMAN -POTATO- BORO CROPPING SEQUENCE

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Planting potato in the late November to early December under T. Aman – Potato-Boro cropping sequence delays the Boro transplanting in late February to early March that reduces the yield of Boro rice due to temperature rise at reproductive phase and thus affects the cropping system productivity which is exacerbated under climate change situation. A study was conducted at the experimental farm of BRRI Regional Station, Rangpur, during 2008-09 and 2009-10 with three planting date, 20, 28 February and 08 March, and four seedling age, 75, 60, 45 and with 75 days as double transplanting (35 in the seedbed and 40 as 1st transplanted) in

Boro season under T. Aman –Potato-Boro cropping sequence in a randomized complete block design with a view to identify agronomic option(s) to reduce the loss of yield of Boro rice in the system. Results revealed that irrespective of seedling age, 28 February and 08 March planting reduced the grain yield of Boro rice at the rate of 49-51 and 69-90 kg $ha^{-1}day^{-1}$ compared to 20 February planting. Again double transplanting of Boro rice increased the grain yield of 14-19, 11-14 and 10-11% over seedling age of 45, 60 and 75 days, respectively. From the results, double transplanting of Boro rice could be an effective option to enhance the system productivity of T. Aman – Potato-Boro cropping sequence by reducing the yield loss of Boro rice under temperature rise situation.

43. COMPETITIVE ABILITY OF RICE CULTIVARS AGAINST WEED SUPPRESSION IN WET SEEDED BORO RICE

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Weed competitive rice genotypes may reduce weed pressure and improve rice productivity. The study was set up during boro 2008 season at BRRI farm Bhanga, Faridpur to observe the magnitude of variety variation for weed suppressive ability and yield under moderate weed competition. Exotic rice varieties.WITAI2, WITA4, WOO-CO and BRRI dhan28 were imposed in sub plots and weed free, unweeeded and one hand weeding were treated as main plot using split plot design. Among the varieties plant height was constantly highest in WOO-CO variety in different days.Leaf area index at PI stage was highest in WOO-CO followed by WITA12 and WITA4 varieties. Highest plant height and LAI at PI stage indicates the weed suppression ability of these varieties. Lowest weed number and weight was also found in WOO-Co which indicate competitiveness with weed of these varieties. Although WOO-CO performed as superior weed suppression ability but grain yield obtained lowest due to its lowest 1000 grain weight. The varieties produced optimum yield in unweeded condition except BRRI dhan28 where WITA12 WITA3 and Woo-Co produced considerable yield in one hand weeded conditions and also in unweeded condition. The study indicates early growth and lower weed biomass can be useful criteria for selecting weed competitive rice cultivars

44. GROWTH, DEVELOPMENT AND YIELD PERFORMANCE OF SOME WHEAT VARIETIES UNDER HEAT STRESS CONDITION

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To observe the effect of high temperature stress on the growth and development of five wheat varieties (Sourav, Pradip, Sufi, Shatabdi and Bijoy) an experiment was conducted at the research field of Sher-e-Bangla Agricultural University from November, 2008 to April, 2009. There were two growing conditions viz. normal sowing (at November 30) and another was late sowing (sowing at 30 December). The late sowing set of wheat plants phased a significant heat stress, especially at the reproductive period that influenced their growth and development pattern. The temperature during the grain filling or grain maturing period was near 23°C in case

of normal seeding and it was about 28°C or above it in late seeding condition. In the normal sowing the germination period was lower than the late sowing treatment as during that time the temperature was higher as compared to late sowing condition where temperature was lower. Days to anthesis and booting also decreased due to late sown heat stress condition regardless the cultivars. Due to heat stress plant height, no. of total tillers, fertile tillers decreased and no. of sterile tillers increases. In the same environment the ear length, no. of spikelet main stem^{-1}, fertile floret main stem^{-1} decreased and no. of sterile floret main stem^{-1} increased. The 1000 grain weight and yield also decreased due to high temperature stress. It was observed that stem dry weight was highest in Shatabdi in normal (2.267 g) and heat stressed (1.801 g) environment and Pradip (1.202 g) and Sufi (1.166 g) produced the lowest stem dry weight in that condition. Leaf number of Pradip (5.37) and Shatabdi (5.01) was the highest in the normal and late sowing condition respectively and it was lowest in the variety Bijoy (4.87) and Sufi (3.62) in the same conditions. Both under normal and late sown heat stressed condition the variety Shatabdi showed the highest leaf area, longest leaf sheath and lamina with concomitant increase of dry matter (5.976 g and 4.459 g tiller^{-1} under normal and heat stress, respectively). However, the spike dry weight was highest in Bijoy and lowest was in Sourav and Sufi regardless the growing condition. In normal sowing the ear weight and husk of main stem was the highest in Shatabdi (2.933 g), whereas seed weight per main stem was highest in Bijoy (2.167 g). In late sown condition, ear weight, seed weight per stem was highest in Bijoy and husk wt. was found the highest in Shatabdi. Grain weight of variety Bijoy (34.94g) and Shatabdi (33.30 g) were higher in late sowing, whereas Sufi had lowest 1000 grain weight (23.81 g) and finally Bijoy produced the highest grain yield both under normal sowing late sown mediated heat stressed condition. Due to heat stress, the yield reduction was 69.53% in Sourav, 58.41% in Pradip, 73.01% in Sufi, 55.46% in Shatabdi and 53.42% in Bijoy.

45. EFFECT OF TEMPERATURE, SHADING AND NITROGEN ON SPIKELET DEGENERATION IN DIFFERENT GRAIN SIZE CULTIVARS

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Pot experiment was done using small, medium and large grain size cultivars BRRI dhan28, Akitakomachi and Arborio, respectively in different environmental conditions to clarify the production of the number of differentiated spikelets (NDS), degenerated spikelets (NDGS) or surviving spikelets (NSS) in different grain size cultivars and dry matter influence on spikelet degeneration. Nine treatments (three day/night temperature, two shading, four N) were applied during panicle formation stage. The NDS, NDGS, NSS and dry matter was determined. BRRI dhan28 produced the higher NDGS to the lower similar day/night (24/24℃) temperature, while Arborio and Akitakomachi to the high day/night (32/24℃) temperature. Heavy shading (75%) significantly increased the NDGS both in BRRI dhan28 and Arborio. High spikelet degeneration was observed due to lower dry matter production. N top dressing at late spikelet differentiation stage in together with the reduction division stage (15 and 10 days before heading) decreased the spikelet degeneration through dry matter increase per stem in small and large grain cultivars. Increase the NDGS for heavy shading and decrease the NDGS for N top dressing suggested that necessity of dry matter for low spikelet degeneration in the larger grain cultivars was more than the small grain cultivars.

46. INFLUENCE OF PLANTING TIME ON GROWTH AND YIELD OF INBRED AND HYBRID CULTIVARS IN COASTAL SALINE ENVIRONMENT

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The experiment was conducted in coastal saline environment at Satkhira to investigate proper planting time that can escape capillary salinity increase and its influence on yield components. BRRI dhan28, BRRI dhan47, BRRI hybrid2, Hira2, ACI-1 and Aloron were transplanted at three different dates starting from December 20, 2008 with around 15 days interval. Growth, yield contributing parameters and water salinity were investigated. The missing plant number and plant height drastically decreased at planting-III. Aloron exhibited the lowest missing plant followed by Hira2 and BRRI dhan47. The spikelet number/panicle was higher at planting-I regardless of cultivars and planting dates and significantly decreased at planting-II. Grain sterility increased much at planting-II in Aloron and ACI and others increased largely in planting-III. Increase in the spikelet number, increased the filled grain number/panicle without significant increase grain sterility (%) and thereby higher yield. Yield was higher in the planting-I and decreased gradually with time in all cultivars. Yield difference among native cultivars and commercial hybrids became greater at planting-III. Increased capillary salinity might be affected native cultivars more than commercial hybrids. Therefore, early planting within the December might be effective for avoidance capillary salinity increase at late season and growing rice with better yield.

47. IMPROVEMENT OF WATER USE EFFICIENCY TURNING THE ATTENTION TO SOIL AIR OXYGEN DYNAMICS

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Global warming caused by the climate change will reduce the amount of irrigation water and the scenario will be worse in the water shortage areas. Different water saving technologies namely, judicious and efficient husbandry of limited soil moisture, utilization of available limited water resources, applying irrigation water considering the upward movement of soil water, reduction of irrigation water at the moisture sensitive growth stages of crop, irrigation considering availability of soil moisture etc were considered important and investigated to increase the water use efficiency. In the developing countries, especially in the uplands crop fields are irrigated by flood irrigation. Due to application of excess irrigation water, soil macro and micro pores are filled with water and therefore, plant roots suffer from soil air oxygen deficiency hampering root development and thus causes reduced plant growth. Therefore, research was conducted on the project - improvement of water use efficiency turning the attention to soil air oxygen dynamics. Developed a technology to directly measure soil air

oxygen using galvanized battery, developed a simple and easy technology to create soil air oxygen deficiency which is a very difficult task - using some low cost wooden boxes and connecting each other by some pipes. Studied the effect of soil air oxygen deficiency on papaya, sugarcane and tomato in the purposively prepared boxes. Results revealed that with the increase of soil air oxygen deficiency root development and shoot dry matter drastically decreased. Plant physiological parameters namely photosynthesis decreased significantly decreased due to soil air oxygen deficiency.

48. ORGANIC MANURING: ITS EFFECT ON RICE YIELD AND SOIL PROPERTIES IN TIDAL FLOODED ECOSYSTEM OF BANGLADESH

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Field experiment was conducted during July 2007 to May 2009 for determining the effect of organic manuring on soil properties and rice yield under tidal flooded ecosystem. Six treatments consisting of poultry liter application (2.0 t ha^{-1}) before Boro (T_1), Sesbania incorporation before T. Aman (T_2), *Lathyrus sativas* incorporation after T. Aman (T_3), red clover (*Melilotus alba*) incorporation before T. Aman (T_4), Chemical fertilizers (T_5) and absolute control (T_6) were compared. Test varieties in T. Aman and Boro season were BRRI dhan44 and BRRI dhan29, respectively. First T. Aman crop was damaged due to SIDR. Second T. Aman gave 3.96 to 4.39 t ha^{-1} grain yield across the treatments and treatment effect was not significant. Both Boro results showed significant response to fertilizer and manure. Absolute control plot yielded 3.66 t ha^{-1}, which increased to 6.09 t ha^{-1} receiving chemical fertilizer (T_5). Application of organic residues increased rice yield compared with chemical fertilizer. The highest yield at the value of 6.71 t ha^{-1} was obtained with T_1 followed by 6.56 t ha^{-1} in T_3. After two years, soil analysis showed an insignificant increase in soil organic matter due to the application of organic residues.

49. ELEVATED CO_2 AND HIGH TEMPERATURE EFFECTS ON PHOTOSYNTHESIS, GROWTH AND PRODUCTIVITY OF SOME INDIGENOUS RICE CULTIVARS OF BANGLADESH

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Effects of rising global CO_2 and temperature on plant growth and productivity have been major concern in current century, but how indigenous rice cultivars response with elevated CO_2 and temperature are not well understood. Therefore, this study was under taken to evaluate the effect of elevated CO_2 and high temperature on photosynthesis, growth and productivity of some indigenous rice cultivars of Bangladesh. Nine rice cultivars viz. moti, binni, khaskani, bunsha, maloti, shakkorkhora, bashful chikon, jhumur and unknown were grown in four environmental conditions. The growing conditions were open top chamber (OTC) with elevated CO_2 (570 ±50 ppm), OTC with ambient CO_2 (~360 ppm), OTC with high temperature (2^oC

high) and field condition. Elevated CO_2 increased photosynthetic rate, leaf area and tiller number and reduced nitrogen in plant components. Contrary, high temperature decreased photosynthetic rate and tiller number while it increased plant height and grain sterility. Elevated CO_2 increased grain yield in all the rice cultivars due to increase in panicle number. Contrary, high temperature negated the stimulatory effect of elevated CO_2 on growth and productivity of rice cultivars. However, there were varietal differences in response to elevated CO_2 and high temperature and indicated the potential genetic materials that would adapt better in future high CO_2 and warmer world.

50. SALT TOLERANCE LEVEL OF RELAY KHESARI WITH T. AMAN AND SWEET POTATO IN SALINE AREA OF NOAKHALI

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Two experiments were conducted in the farmers' field of FSRD site, Hazirhat, Noakhali under rain fed condition during the Rabi season of 2009-10. The objective of the study was to assess the salinity tolerant level of Local grass pea and vines of different sweet potato varieties in the farmers' field condition and to observe the emergence percentage, plant stand establishment and plant survivility in different salinity gradient. The vine of different sweet potato verities (i.e. BARI SP-8, BARI SP-9 and Local) were planted in the farmers' field on last week of December, 2009 and relay khaseri was seeded on first week of November, 2009. During seeding time of rely khaseri the initial soil salinity of field was 1.2 to 2.1 dS m^{-1} and 2 to 4 dS m^{-1} in vine transplanting time of sweet potato. The highest plant population 89% was observed in local variety when soil salinity ranged 2.5-6.80 dS m^{-1} (at 20 DAP) followed by 83% plant population in BARI SP-9 and lowest plant population 51% found in BARI SP-8. In the vine spreading stage soil salinity level ranged 3.17 to 13.40 dS m^{-1} and the highest plant population (72%) observed in local variety at 7.10 dS m^{-1} and lowest (49%) in BARI SP-8 in the same soil salinity level. BARI SP-9 (23.53 t/ha) varied significantly with the local variety (17.77 t/ha) in respect of root yield. Salinity had significant affect on emergence percent of rely khaseri. Increasing salinity reduced similarly various growth parameters including length of shoots and roots, fresh weight, dry weight and yield at > 8 dS m^{-1} in seed formation stage. The present study suggested that, in the field condition where the initial salinity rise up to 3 dS m^{-1} and 4 dS m^{-1} are highly suitable and economically profitable for grass pea and sweet potato cultivation, respectively.

51. RICE ALLELOPATHY: A POSSIBLE MEANS TO OVERCOME THE RISK OF WEEDYNESS IN FUTURE CHANGED CLIMATE

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Due to increased greenhouse gas effects the atmospheric temperature is going to increase which will lead to increased weed infestation in rice cultivation. Rice allelopathy might be a solution to this burning issue. Allelopathic potentialities of 139 rice varieties/accessions were evaluated

against *Echinochloa crusgalli* following the relay seeding technique under laboratory condition at the Bangladesh Rice Research Institute, Gazipur. Reduction in root length, shoot length and seedling dry matter of the test weed due to allelopathic effects of rice accessions was estimated and the average percent inhibition due to rice allelopathy was calculated. Thirteen rice varieties/accessions including Kataribhog, Woo co Chin Yu (Woo co), WITA12, Dular, Lalpaika and BRRI dhan27 caused more than 60% weed inhibition. Although some of the local varieties had strong allelopathic property, in general the modern varieties under trial produced the greater inhibition of the weed. The late maturing (< 140 days) varieties were more allelopathic than early maturing ones. Under greenhouse conditions the double-pot technique was used both in aman and boro seasons with the selected rice varieties to separate the effects of competition from allelopathy. The selected highly allelopathic varieties (as per laboratory screening) also caused significant weed inhibition in both the seasons. In aman, Kataribhog, FARO8, WITA8, WITA12, BRRI dhan39 produced 51 to 59% weed inhibition and in boro, Kataribhog, Woo co, WITA3, IR64, BR26 and Dular produced 47 to 55% weed inhibition.

52. EFFECT OF BRRI DHAN 46 AS LATE TRANSPLANTED AMAN RICE

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This experiment was conducted to find out the cut of date of delay planted modern variety BRRI dhan46 at Bangladesh Rice Research Institute (BRRI) Farm, Gazipur in T. Aman season, 2006 and 2007. BRRI dhan46 was transplanted with BR22 and Nizersail from 15 September in 2006 and from 05 September in 2007 to 15 October in both years, with 10 days interval. Thirty days old seedlings were transplanted in every planting and were fertilized by 70-15-30-10 kg NPKS/ha. Modern variety BR22 and BRRI dhan46 produce comparable tillers/m^2, which were significantly lower than Nizersail, but the grains/panicle and panicle length gradually decreased among the test varieties irrespective of planting dates. Grain yield of BRRI dhan46 was significantly higher than other test varieties irrespective of planting dates due to heavier individual grain weight and higher grains/panicle and panicle length among the test varieties. BRRI dhan46 can be planted up to 25 September that gave 3.98 and 3.2 t/ha grain yield in 2006 and 2007 which was 0.8 and 1.0 t/ha higher than BR22 and 1.1 and 1.4 t/ha higher than Nizersail, respectively.

53. SCREENING FOR DROUGHT STRESS TOLERANCE IN AUS RICE

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In Bangladesh, rainfed lowland rice occupies about 5.8 million ha of which 40% is severely affected by drought. Thus, the scientists are trying to improve rice variety tolerant to drought. The study was conducted under normal and drought conditions to evaluate the extent of phenology, growth and yield responses of 14 diverse rice genotypes to drought stress and to identify traits that may confer drought tolerance. Analysis of variance indicated highly

significant differences among the genotypes for all the traits studied. Some promising cultivars were found to be tolerant against drought stress at different growth stages i.e. vegetative stage, flowering stage, and 7 & 14-day after flowering. Water stress delayed phenological events possibly due to impairing vegetative growth encountering stress. Plant height affected significantly under water stress conditions. All the genotypes showed a marked reduction in root dry weight, albeit some recovered to a great extent. Among different growth stages, flowering stage drought affected most in almost all plant traits. The results showed that the genotypes viz: Bhora bhadui, Bhadai, BRRIdhan 42 and BRRIdhan 48 were the best entries under drought conditions, where they possess many desirable traits like higher number of tillers and panicles per plant and minimal grain sterility which are useful for drought tolerance.

54. SUBMERGENCE TOLERANT RICE VARIETIES AND THEIR MANAGEMENT OPTION FOR NORTH-WESTERN REGION OF BANGLADESH

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Flash flood submergence is one of the natural hazards of rice production which is becoming more abundant due to global climate change. Efforts were undertaken to find out the adaptability and management option for submergence tolerant rice varieties. There was flash flood for the duration of 17 days in the trial conducted at Kachir Char in Kurigram. In this trial, the highest survival (%) was obtained from IR64-Sub1 (92%), followed by Swarna-Sub1 (78%) and Sambha Mashuri-Sub1 (75%). Swarna-Sub1 produced 4.1 t/ha grain yield which was around 1.7 ton more than the check variety Swarna. In BRRI, Rangpur, eight Sub1-lines along with two check varieties viz. BR11 and Swarna were tested under controlled submergence (14 days), rainfed and double transplanted conditions. Average performances of all the entries reflected that highest yield performance was obtained from double transplanted trial (5.0 t/ha) followed by from rainfed trial (4.0 t/ha) and controlled submergence trail (3.5 t/ha). Regarding management options, top dressing of urea and potassium within 10 days after flood water recession followed by weeding and sanitation is the best for better recovery, survival and yield of submergence tolerant rice. Potassium application as 50% basal + 25% after desubmergence + 25% 5 days before PI was most effective. It is expected that the submergence tolerant varieties will be widely up scaled through seed networking activities.

55. EFFICIENT APPLICATION OF COMPOST IN ORGANIC FARMING SYSTEMS

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As an alternate method of crop production, organic farming is now being practiced in many developed countries and most of the organic farmers use composts instead of synthetic agro-chemicals. The land application of organic compost is certainly not a new phenomenon but today, with renewed interest, research is needed to determine how compost can be used efficiently to replace hazards synthetic chemical fertilizers and herbicides for crop production. This study was designed with the aim of determining the effects of application methods of green tea waste - rice bran compost (GRC) such as pre-sowing incorporation (PSI) with soil and post-sowing mulching (PSM) on soil of compost at the rate of 0.5, 1.0 and 2.0 kg m^{-2} with control (only soil) for crop production and weed control. This study mentioned the effective way of GRC application for enhancing seed germination and seedling growth, improving crop productivity and quality, and suppressing weed emergence during cultivation of spinach and radish. Among the two application methods, PSM reduced the water losses from the upper surface of soil and also maintained lower EC of the surrounding soils of seeds during germination those were responsible for enhancing seed germination and plant growth. This study suggest for the efficient and economic application of GRC as PSM of 1.0 kg m^{-2}.

56. USE OF PESTICIDES IN VEGETABLE FARMS AND ITS IMPACT ON HEATH OF FARMERS AND ENVIRONMENT

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Irrational use of pesticides is increasingly threatening our ecosystem, health and environment. This study investigated the use of pesticides in vegetable farms and its impact on health and environment. Three contrasting sites under three sub-districts where vegetable production were common were considered for this study. From each sub-district 60 farmers who had been using pesticides application for growing vegetables were selected randomly. Findings reveal that the use of pesticides in vegetable farms was higher and frequent. Higher doses of pesticides were used in the high cropping intensity areas and doses of application were positively increasing for all three categories of cropping intensities. Yearly increase of pesticides use was around 1-2% among the study sites. Most of the farmers knew the importance of taking protective measure during pesticides application. However, 85-90% of farmers were not accustomed to take any protection during pesticide application as well as preservation and transportation. People aged 21-40 years were relatively highly exposed to pesticide poisoning. This study found that selection of pesticide, dosage and mode of application were based on agro-chemicals dealers' suggestion. During pesticide use, farmers felt burning sensation of skin, breathing problem, itching, and dizziness and burning in their eyes. Around 27% perceived that fish had been reducing and water pollution occurred due to wash-out of agrochemicals from agricultural farms. Intensive awareness training of farmers on safety measures regarding application of pesticides and its rational use is necessary to avoid potential health and environmental hazards.

57. GROWTH AND YIELD OF HYBRID AND INBRED BORO RICE AFFECTED BY DIFFERENT METHODS OF WEED CONTROL

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A field experiment was carried out at Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from December, 2008 to May, 2009 to evaluate the growth and yield of hybrid and inbred *boro* rice as affected by different weed control methods. The experiment comprised of seven weeding treatments and three variety of *boro* rice. The experiment was carried out in RCBD with three replications. Eight weed species belonging to four families were identified in the experimental field. Densities of weeds were recorded from 7 DAT to 50 DAT at 7 days interval. It was found that among the weed control treatments, application of Sunrice 150WP (Ethoxysulfuran) 125 g a.i. ha^{-1} showed best performance in respect of the highest plant height (103.35cm), maximum tillers $hill^{-1}$ (22.00), the maximum plant dry matter (192.8g $hill^{-1}$), effective tillers $hill^{-1}$ (20.34), lowest number of ineffective tiller $hill^{-1}$ (1.33) and consequently produced highest grain yield (9.50 t ha^{-1}), straw yield (10.25 t ha^{-1}) and harvest index (41.16) in comparison to all other treatments. Among the weed control treatments- Sunrice 150WP (Ethoxysulfuran) 125 g a.i. ha^{-1} control 81% weed population, where as Commit 500EC 62% and hand weeding only 52% which was costlier than others. The highest grain yield, straw yield as well as benefit cost ratio was obtained from the variety Sonarbangla hybrid dhan 6. Application of Sunrice 150 WP (Ethoxysulfuran) 125 g a.i. ha^{-1} increased 22.58% grain yield than Commit 500EC (Pretidachlor) 750 ml ha^{-1} and 34.58% grain yield than two hand weeding due to higher number of panicles $hill^{-1}$ and higher number grains $panicle^{-1}$

58. YIELD RESPONSE OF DIFFERENT CHEWING TYPE SUGARCANE CLONES UNDER FARMERS FIELD CONDITION

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Sugarcane is a cash- cum-industrial crop of Bangladesh. But one third of the total production is used as chewing purpose. An experiment was conducted with five chewing clones namely Amrita, Bonpara gandary, Rangbilash, Co 527 and Isd 24 at farmer's field of Tala, Satkhira and Mollarhat, Bagherhat, Bangladesh during cropping season 2008-09 to find out the suitable clones for chewing purpose. The experiment was setup in a RCB design with three replications. Both the location has significant effect on yield contributing characters like tillering, number of millable stalk, yield of cane and brix percentage. In farmers field at Tala, Satkhira the highest cane yield was obtained from Amrita (102.25 tha^{-1}) followed by Rangbilash (97.22 tha^{-1}) where the lowest was found in Isd 24 (62.82 tha^{-1}). On the contrary, farmers field at Mollarhat, Bagherhat highest yield was obtained from Amrita (115.56 tha^{-1}) and the lowest on with Isd 24 (68.63 tha^{-1}). In case of brix percentage the highest was obtained from Rangbilash (20.15%) in both the locations. In the context of benefit cost ratio (BCR) Amrita and Rangbilash gave the highest values of 2.35 and 3.56 respectively in Tala, Satkhira where 2.15 and 2.65 in farmer's field at Mollarhat, Bagherhat.

59. PERFORMANCE OF SUGARCANE AS RELAY CROP IN RICE AND SUBSEQUENT INTERCROPPING

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This study was conducted during the cropping year 2004-2005 to 2006-2007 at the Bangladesh Sugarcane Research Institute farm to investigate the performance of the possibility of sugarcane production as relay crop with rice (T. Aman) and cultivation two successive intercrops with sugarcane after harvesting rice. The experiment was laid out in split plot design with three replications. In relay cropping system, sugarcane setts/settlings were planted/transplanted in previously kept vacant spaces of rice field after flowering stage. Fertilizers and management practices for rice, sugarcane and other crops under study were practiced according to the recommendation. After harvesting of rice, potato as first and mungbean as second intercrop were grown successively in the space where rice was grown. The treatment factors were as follows: Factor: A : A_1 = Sugarcane relayed in rice; Factor : B : B_1 = Paired row cane; A_2 = Sugarcane after rice, B_2 = Single row cane; Factor: C : C_1 = STP Intercrops : 1^{st} Intercrop : Potato, C_2 = Conventional, 2^{nd} Intercrop : Mungbean. Mean value of different parameters of the cultivated crops in the experiment revealed that rice yields (6.38 t ha^{-1}) were identical both the production systems but yields of intercrops were higher in sugarcane followed by rice production systems. The yield contributing factors of sugarcane were varied with the difference of planting systems. Mean value of tillers (207.7 $\times 10^3$ ha^{-1}), millable canes (164.79$\times 10^3$ ha^{-1}), and cane yield (103.38 t ha^{-1}) were obtained higher where sugarcane was relayed with rice and in both the production system STP method resulted better than conventional planting method. It may be concluded that relay cropping system was found superior in all respects compared to the system of sugarcane cultivation after harvesting of rice and can be recommended for large adoption in farmers' field.

60. EFFECT OF PLANTING DATE ON GROWTH, YIELD AND JUICE QUALITY OF SUGARCANE

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An experiment was conducted at the experimental farm of the Bangladesh Sugarcane Research Institute (BSRI), Ishurdi, Pabna during the period from October, 2007 to March, 2009 under the AEZ 11 (High Ganges River Flood Plain soils). The experiment was carried out to find the effect of planting date on growth, yield and juice quality of sugarcane. Six planting dates of mid October to mid March were laid out in a Randomized Complete Block (RCB) design with four replications. The highest germination percentage (68.29) was at October planting and gradually decreased with the following planting dates and the lowest of 53.32% was recorded from mid March planting. Growth characters like tillers, millable cane stalks, internodes per stalk, cane height, girth and unit stalk weight were significantly influenced by different planting dates. The values of all the yield contributing factors and quality parameters were higher in early planted crops compared to late planting contributed by the higher number of tillers, millable cane stalks, greater stalk length and weight. Maximum benefit-cost ratio of 1.79 was found from October planting followed by November planting and gradually decreased with proceeded planting dates. For higher cane and sugar yield as well as maximum economic

return, the overall results advised to plant sugarcane during the month of October to November and for late planting under certain cases, it is better to plant in the month of February.

61. WATER RELATIONS, DRY MATTER PRODUCTION AND YIELD OF FOUR MUNGBEAN CULTIVARS UNDER WATER STRESS IMPOSED AT FIRST FLOWERING

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A pot experiment was conducted under a rain-out shelter at Bangabandhu Sheikh Mujibur Rahman Agricultural University, Salna, Gazipur with four mungbean cultivars- two relatively tolerant (Barimung 2 and BUmug 2) and two relatively susceptible (Barimung 6 and ML 613) to water stress that imposed throughout the growing period. In this experiment, stress was created by stopping water supply from first flowering to till wilting of leaves and thereafter re-watered with normal irrigation up to harvest. Water stress reduced leaf water potential (LWP), relative water content (RWC), exudation rate (ER), shoot and root dry matter at wilting, in all the mungbean cultivars. Chlorophyll content at wilting was reduced due to water stress in ML 613 and BUmug 2, whereas, increased in Barimung 6 and Barimung 2. The reduction of LWP and RWC at wilting was higher, while the values of ER at wilting, and shoot and root dry matter at both wilting and harvest were lower in Barimung 6 and Barimung 2 compared to the other two cultivars. Barimung 6 showed the highest relative seed yield (0.74), followed by Barimung 2 (0.72), ML 613 (0.55) and BUmug 2 (0.39); which indicated that Barimung 6 and Barimung 2 were relatively tolerant to water stress at first flowering compared to ML 613 and BUmug 2.

62. STUDY THE GROWTH AND YIELD OF GINGER UNDER DIFFERENT NITCHES

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The experiment was conducted at Spices Research Center, BARI, Bogra to scientifically validate the farmers days old belief of ginger adaptability to shade condition. The study results revealed that among the different tested types and degrees of shade imparted for ginger growing, the best performing one was cucurbit trailees with intermittent light and shade that gave significantly higher ginger yield (15.07 t/ha), followed by Dhaincha, Jackfruit and Cinnamon shade(10-11 t/ha), respectively. However, in terms of ginger yield with PAR incident on ginger was found positively related. While, observed water use and transpiration rate was moderately associated with yield. But, the data on CO_2 use and photosynthetic rate at

one month's interval could not explain the attained yield. It might be due to higher photosynthetic efficiency of ginger besides its longer field duration, needs frequent data collection. In case of yields correlation with traits, creeper trailees shade had also shown positive association of tillers and leaves/clump and of leaf area with ginger yield.

63. STUDY ON SUITABILITY AND CROPPING INTENSITY THROUGH RELAYING WHEAT WITH POTATO AT JAMALPUR REGION

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Potato-wheat relay cropping system was conducted in Jamalpur district during 2008-09 to evaluate the suitability and cropping intensity. Wheat was planted in potato field at 40 days after finishing of earthing up of potato crop and top dressing of nitrogen fertilizer. The yield of potato was affected due to relay cropping compare to sole crop (ranging from 6.25 to 7.09 t/ha). The highest potato yield (7.09 t/ha) was obtained in sole potato crop which was at par with that obtained in one line wheat in between two potato bed. The highest grain yield of wheat was obtained from sole wheat treatment. The highest LER (1.30), gross return, net return and BCR (2.69) was obtained from one line wheat relay cropped with two bed of potato

64. IMPROVING PRODUCTIVITY AND SUSTAINABILITY IN WARMER AREAS THROUGH RESOURCE CONSERVING TECHNOLOGIES: SAVE WATER AND REDUCE GLOBAL WARMING

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Rice-wheat (RW) cropping systems are critical to food security of increasing population in Bangladesh. However, the sustainability of RW systems is threatened by productivity decline and environmental sustainability. Crop production on permanent raised beds (PRB) with straw retention is expanding worldwide as a way to increase system productivity, diversify cropping and reduce global warming. When coupled with raised beds with straw retention can improve soil moisture retention, soil health, crop productivity and sustainability. A 3 years study was conducted at the Regional Wheat Research Centre, Rajshahi, Bangladesh as a warmer area, to compare the effects of under five N fertilizer levels (0, 50,100,150 and 200 % N of recommended dose) and two straw retention(SR)/tillage treatments (100% SR of all crops+ Permanent raised beds(PRB), 0% SR +PRB, 100% SR+ Conventional tillage practice (CTP) and 0% SR+ CTP in a intensified RW systems by adding a third pre-rice crop of mungbean. Permanent beds with straw retention produced the highest productivity for all three crops in the sequence. Within each N rate the total system (rice-wheat-mungbean) productivity was greatest with 100% SR on PRB and least in CTP with zero straw retention. At 100% of recommended fertilizer N rate, mean annual system productivity was 12.5 t/ha for PRB with 100% SR, 11.2 t/ha with PRB without SR and 10.3 t/ha with CTP without straw. System productivity in N unfertilized plots increased when straw was retained due to increased supply and uptake of N. The results suggest that N fertilizer rates can be reduced when straw is retained. Soil organic matter in surface soil layers of the PRB had increased by 0.22% after 3 years (3 rice-wheat-

mungbean crop cycles) with straw retention, with a greater increase with 100% SR. Straw retention is an important component of crop sustainability and may have long term positive impacts on soil fertility. Water use efficiencies improved 25, 23 and 29% in wheat, rice, and mungbean crops, respectively when 100% SR with PRB system. By sowing crops on raised bed, irrigation water moves laterally from the furrow to the top and middle of the bed by capillary flow. Resource conserving technology required 103.8 l/ha fuel per year compared to conventional method 135 l/ha/year. 31.2 litre/ha/year fuel saved by resource conserving technology in rice-wheat-mungbean system. Compared with conventional tillage with all crop residues removed, the combination of PRB with residues retained appears to be a very promising technology for sustainable intensification of RW systems in Bangladesh.

65. CASSAVA- A NEW POTENTIAL CROP FOR HUMAN AND ANIMAL FOOD IN BANGLADESH: EFFECT OF CULTIVATION PROTOCOL ON TUBER AND BIOMASS YIELD

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Cassava is a minor crop in Bangladesh. Starchy tubers (roots) are used as staple food; feed, and raw materials in industries. Cassava would be an ideal crop under changed climate since the crop possesses diseases, pest and drought tolerance, and can be grown in poor soils where most other crops fail. Selection of cassava accessions were completed based on nutritional and toxic contents. Methods of removing toxicity were suggested. The effects of different protocols such as methods of planting stem cutting (horizontal, vertical and lateral) and depth of planting (8, 12, 18 cm deep) were investigated using two accessions, 'Comilla' and 'Khagrachari'. Of the three planting positions, both the accessions produced better yield when planted horizontally. Fresh tuber (FT) yield, for example, was 48.14 and 37.06 t/ha in Comilla and Khagrachari respectively, while total dry mass (TDM) yield was 32.03 and 30.95 t/ha in the former and latter accessions, respectively. Among depths of plantings, FT and TDM yield was 50.51 and 33.08 t/ha, respectively in Comilla while they were 42.23 and 33.19 t/ha, respectively in Khagrachari at12cm. Considering adaptability, yield and diversity of utilization, the crop would be a potential one for human and animal food in Bangladesh.

66. DRY MATTER ACCUMULATION AND PARTITIONING IN DIFFERENT PLANT PARTS OF MUNGBEAN AS INFLUENCED BY SOWING DEPTH AND SEED SIZE

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A field experiment was carried out at the Sher-e-Bangla Agricultural University (SAU) farm, Dhaka, Bangladesh during March to June 2007 to investigate the influence of varying seed size and depth of sowing on dry matter accumulation and partitioning in different plant parts of mungbean. The treatment comprised of three sowing depths viz.. 2, 4 and 6 cm and three seed sizes viz. < 3.2 mm, 3.2 mm to 4 mm and > 4 mm. The experiment was laid out in a split-plot

design with three replications having sowing depth in main plots and seed size in sub-plots. Results showed that 4 cm depth, Seed size of > 4 mm and its interaction had significant influence on most of the plant parts. The 4 cm sowing depth with > 4 mm seed size showed the highest dry weight of leaf (5.585 g/plant), stem (4.9 g/plant), inflorescence (12.84 g/plant) and total dry weight (25.69 g/plant). But, 2 cm depth with S_3 showed the highest dry weight of root (2.54 g/plant). Positive correlations were observed among the plant parts. The correlation between dry matter accumulation in leaf and stem were found to be significant. The relationship between inflorescence and the total dry matter was highly significant at the harvest. The interaction treatments Sowing depth 4 cm with seed size from 3.2 to over 4mm and also 6 cm depth with the seed size below 3.2 mm showed the greater efficiency in dry matter partitioning in inflorescence (around 50% of total dry matter) at the maturity.

67. INFLUENCE OF SOWING DEPTH AND SEED SIZE ON DIFFERENT PHYSIOLOGICAL ATTRIBUTES OF MUNGBEAN

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A field experiment was carried out at the experimental farm of Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh during March to June 2007 to investigate the influence of varying seed size and depth of sowing on the physiological attributes of mungbean. The experiment was consisted of three sowing depths (2, 4 and 6 cm) and three seed sizes; small (< 3.2 mm), medium (3.2 mm to 4 mm) and large (> 4 mm). The experiment was laid out in a split-plot design with three replications having seeding depth in the main plots and seed size in the sub-plots. Results showed that the sowing depth, seed size and their interaction significantly affected the physiological attributes of mungbean. The significant highest plant height at 60 DAS (68.81 cm), leaf area index at 45 DAS (7.70), number of branches/plant at 45 DAS (1.69) and number of leaflets/plant at 45 DAS (29.39) were obtained with the interaction treatment of medium depth and largest seed size. Crop growth rate increased with age from 15 – 45 DAS and significant highest CGR (1.17) was obtained at 45 DAS with smallest seed size sown at 4 – 6 cm depth. Net assimilation rate decreased from 30- 45 DAS and highest NAR (7.21) was found at 30 DAS with the medium seed size sown at 2 cm depth.

68. EMERGENCE AND SEEDLING ATTRIBUTES OF MUNGBEAN AS INFLUENCED BY SOWING DEPTH AND SEED SIZE

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An experiment was conducted at the Agronomy field laboratory of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from March 2007 to June 2007 to find out the influence of varying sowing depth and seed size on emergence and seedling growth of mungbean cv. BARI mung - 5. The experiment was consisted of three sowing depths (2, 4 and 6 cm) and three seed sizes; small (< 3.2 mm), medium (3.2 mm to 4 mm) and large (> 4 mm).

The experiment was laid out in polybags following split-plot design using depth as the main factor and seed size as sub factor. Results showed that the percentage of emergence was significantly the highest at 2 cm depth. However, significantly the highest hypocotyle length, root, shoot and total fresh weight were found in maximum depth (6 cm). In respect of seed size, results showed that the small sized seeds had significantly the highest seedling emergence. While the larger seeds showed significantly the highest epicotyle and hypocotyle length, fresh weight of root, shoot and total seedlings. Among the interaction treatments, the highest hypocotyle length, fresh weight of root, shoot and total seedlings were found in maximum depth with larger seeds.

69. INFLUENCE OF SOWING DEPTH AND SEED SIZE ON DIFFERENT YIELD ATTRIBUTES AND YIELD OF MUNGBEAN

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A field study was conducted at the experimental farm of Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh during the period from March 2007 to June 2007 to find out the influence of varying seed size and sowing depth on yield attributes and yield of mungbean. The experiment was consisted of three sowing depths (2, 4 and 6 cm) and three seed sizes; small (< 3.2 mm), medium (3.2 mm to 4 mm) and large (> 4 mm). The experiment was laid out in a split-plot design with three replications having depth in the main plots and seed size in the sub-plots. Results showed that the sowing depth of 4 cm showed significantly the highest values in number of pods plant^{-1}, number of seeds pod^{-1}, pod length, 1000 grain weight, seed yield and harvest index. In all the cases, significantly the lowest values were obtained with 2 cm sowing depth. The highest pod length (10.15 cm), 1000 grain weight (42.67 gm) and seed yield (1.44 t ha^{-1}) were obtained with the largest seeds. The highest number of pods plant^{-1} (13.11), number of seeds pod^{-1}(9.97), pod length (10.14 cm), 1000 grain weight (43.45 g), seed yield (1.451 t/ha) and harvest index (25.44%) were observed in medium depth. Interaction effect of the largest seeds with medium depth showed the highest values in number of pods plant^{-1} (13.28), number of seeds pod^{-1} (10.24), pod length (10.93 cm), 1000 seed weight (44.09 g), seed yield (1.515 t/ha), harvest index (15.73%) and shelling percentage (32.55%). Except harvest index and seed yield/ha, all other yield contributing characters were found to be significantly correlated.

70. EFFECT OF DIFFERENT SOWING DATES ON SEED YIELD AND QUALITY FOR KENAF AND ROSELLE CROPS

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An experiment was conducted to assess the feasibility of growing Kenaf and Roselle crops for seed yield and quality from seed to seed crop in different dates of sowing. The experiment was laid out at Jute Agriculture Experimental Station, Manikganj in a randomized complete block

design with Kenaf (*Hibiscus cannabinus*) for cv. HC-2 and Roselle (*H. Sabdariffa*) for cv. HS-24. Seeds were sown at ten different dates of sowing starting from May 15 to September 30 with an interval of 15 days. Results revealed that seed yield and yield attributes differed significantly due to different dates of sowing. Seed yield of Kenaf (375 $kgha^{-1}$) and Roselle (369 $kgha^{-1}$) were recorded in May 15 sowing and in August 15 sowing the yields were 335 $kgha^{-1}$ and 327 $kgha^{-1}$, respectively for the crops. Seed yield significantly declined from August 30 and onwards. Interaction of date×variety was found significant in Kenaf and Roselle for seed yield and some of seed yield attributes. Similar results were observed in terms of seed quality viz, germination, moisture content, vigour and seed health. So Kenaf and Roselle crops could be raise in the field from May 15 to August 15 for higher seed yield and quality as well.

71. ENSO EFFECTS ON RICE PRODUCTION IN BANGLADESH-II

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The objective of this study is to find the relationship between ENSO and rice production system (rice area, production or yield in percent deviation). We consider four administrative units having contrasting ecological backgrounds. The ecotype specific rice data i.e. rainfed lowland, rainfed upland and irrigated rice with respect to each district is not considered in this study as the data is not available in that format from Bangladesh Bureau of Statistics (BBS). Our analysis indicates the rice area, production and yield could not be systematically or satisfactorily justified by rainfall and or by ENSO. However, a few reasonable correlations, though not significant might have some sense. The coastal district Khulna experiencing moderate rainfall, salinity and tidal surge (in every two to three years) express some dependence of rice yield on ENSO. From the regression equation it is observed that 1° C rise of July, August and September SSTA decrease 2.947%, 3.210% and 2.544% yield, respectively. The other districts Rajshahi (drought prone), Barisal (non-saline tidal prone) and Sylhet (abounding with rain) demonstrate a few sporadic relationship between ENSO and rainfall and rainfall and rice production system but not between ENSO and rice production system. Accordingly, it appears that the impact of ENSO in rice agriculture in Bangladesh might not be equally applicable. More study through different analytical approach including some more parameters might yield better results.

72. RESPONSE OF MAIZE TO ALLELOPATHIC WATER EXTRACTS WITH AND WITHOUT FERTILIZER

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Allelopathic crop water extracts of sorghum, sunflower and brassica may affect the growth and yield of maize and its associated weeds. The allelochemicals and soil fertility can interact by

influencing the crop growth. To investigate these aspects present study was carried out at the Agronomic Research Area, University of Agriculture, Faisalabad, Pakistan during autumn 2009. Experiment was laid out in randomized complete block design (RCBD) with four replications. A mixture of three water extracts viz. sorghum, sunflower and brassica each at 15 L ha^{-1} were applied as foliar sprays, once (7 DAS), twice (7 and 30 DAS) and thrice (7, 30 and 52 DAS) in plots with no fertilizer and plots receiving NPK fertilizer at 175+100+60 kg ha^{-1}. A control treatment receiving no fertilizer and no allelopathic spray was maintained for comparison. The results revealed that two foliar sprays of allelopathic water extract mixture increased maize grain yield by 49% when no fertilizer was applied, while the fertilizer alone improved the yield by 25%. The two foliar sprays of allelopathic extracts with fertilizer increased maize yield by 82%. The increase in maize yield was due to weed suppression by allelopathic water extracts up to 74%. Economic analysis suggested that two foliar sprays of allelopathic water extracts were economical due to higher net returns of PKR 88547 ha^{-1} as compared to all other treatments.

73. GRAIN GROWTH AND YIELD OF CHICKPEA AS INFLUENCED BY SOWING DATE INDUCED TEMPERATURE VARIATION

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A field experiment was conducted at the research farm of Bangladesh Agricultural Research Institute, Joydebpur, Gazipur during rabi seasons of 2008-09 and 2009-10 to evaluate grain growth and yield of chickpea (var. BARI chola-5) in prevailing temperatures at different sowing dates (November 10, November 20, November 30, December 10, December 20 and December 30). Sowing dates showed great influence on the variation in prevailing temperatures. Reproductive stage of November 20 sown crop received comparatively low air temperatures (Min. 10.5 to 20 ^{o}C and Max. 22 to 34.5 ^{o}C) than that of other sowing dates (Min. 15.5 to 27 ^{o}C and Max. 29 to 35.5 ^{o}C), which favoured longer reproductive stage (54 to 62 days) and gave higher grain yield. In general, high temperature increase grain growth rate, enhance maturity but decrease grain yield. In the present study, grain growth rates (15.50 to 16.78 mg/grain/day) of delay-sown crops were higher than those of early sown crops (10.48 to 12.84 mg/grain/day) with reduced reproductive stage (41 to 44 days) due to high air temperatures (Max. 29.91^{0}C and Min.15.18^{0}C). As a result, delay-sown chickpea gave lower grain yield than that of early sown chickpea. The highest grain yield (1873 kg/ha) was recorded in November 20 sown chickpea while the lowest in December 30 (1154 kg/ha). Sowing beyond November 20, grain yield reduced by 9 to 38%.

74. RISE IN ATMOSPHERIC CO_2 AND ITS IMPACT ON CROP PRODUCTIVITY: RESEARCH AND TECHNOLOGY: SOUTH ASIAN STUDIES

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Global climate changes are unique challenges to the agro ecosystems. Human activities have altered the global atmosphere effecting the land environment. The doubling of human population in next five years

will intensify such pressures. These anthropogenic changes in atmospheric composition and climate will significantly influence the performance of crop. The exponential rise in the atmospheric CO_2 is an important global climate change, which effectively influences the productivity of the crop plants. Innovative approaches, for conducting long-term experiments to study the responses of crop plants to the elevated CO_2, have been developed. Open top chamber CO_2 enrichment technology was designed and developed for south Asian conditions to study the effect of elevated CO_2 in the crop plants. CO_2 enrichment research network of India, Bangladesh, Nepal, Pakistan and Sri Lanka for multi country, multi disciplinary experiments is being coordinated by the national fellow program of the Indian Agricultural research Institute New Delhi (Uprety et al 2000). A PC based system of Free Air CO_2 enrichment (FACE) technology was established with the help of National Physical Laboratory New Delhi, to generate realistic biological data on the crop responses to the higher CO_2 concentration.
Addition of these facilities has brought India on the GCTE CO_2 research Network which is active in tackling vulnerable issues and adaptation strategies for meeting the rise in global food demand in the face of global environmental changes.
Field experiments, for studying the responses of crop plants to the elevated CO_2 using OTC and FACE facilities were conducted at IARI under a global change national programme. Following conclusions were drawn: Elevated CO_2 was highly significant in mitigating the adverse moisture stress effect on plant processes in *Brassica* species. There is a possibility of transferring CO_2 responsive characters from one parents *Brassica campestris* to the hybrid *Brassica oxycamp*. Studies on rice and wheat cultivars demonstrated significant increase in their growth and productivity these responses have been physiologically and bio chemically characterize. This information is an important component for decision support system for strategic choice of crop cultivars to be promoted in agricultural area vulnerable to global environmental change to sustain the livelihood in affected resource poor farmers.

75. IMPACT OF CLIMATE CHANGE ON INDIAN AGRICULTURE

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The increase in global air temperature, ocean temperature, uncertainity in precipitation and occurrence of extreme events like droughts and floods, melting of glaciers and snow covers, rise in mean sea level, increased frequencies of coastal flooding, etc. clearly indicate that climate is changing. The global concentration of green house gases (GHGs) like carbon dioxide, methane and nitrous oxide has increased significantly due to human activities. The carbon dioxide, methane and nitrous oxide concentration in atmosphere has increased from 280 ppm, 715 ppb and 270 ppb in 1750 AD to 379 ppm, 1774 ppb and 319 ppb in 2005. IPCC has reported that the increase in GHGs has lead to increase in air temperature by 0.74^0C between 1906 and 2005 (IPCC, 2007a). The eleven of last twelve years (1956 – 2006) rank among the warmest twelve years, the rate of warming has been much higher in the recent years. The global average sea level rose at an average rate of 1.8 mm per year during 1906 to 2003 and at an average rate of 3.1 mm per year from 1993 to 2003. The climate studies revealed increasing trend in summer monsoon rainfall over western Indo – Gangetic Plain Region (IGPR) from 1900, decreasing trend over central IGPR from 1939 and eastern IGPR, i.e., an westward shift in rainfall over the IGPR. It is projected that by the end of 21st century rainfall over India will increase by 15-40% and the mean annual temperature by 3-6^0C (NATCOM, 2004). Warming will be more pronounced in northern India. Presently about 68% area of our country is liable to

droughts, 8% area is prone to cyclone and 40 million area ($1/8^{th}$ of the total area) is prone to flood.

These environmental changes are likely to put further pressure on Indian agriculture. The analysis of the historical data on yields of rice and wheat using the results of long term experiments, modelling studies etc., indicated that rice yield is showing a declining trend during last three decades which is partly related to the changing climatic conditions, particularly that of increasing night temperature. Increase in CO_2 concentration will increase the photosynthetic efficiency in C_3 plants like rice, wheat, etc. thereby increasing their yield. However, the increase in temperature and uncertainty in rainfall will mask the effect of elevated CO_2 and reduce the production. The recent studies carried out in Indian Agricultural Research Institute indicated that every rise of 1^0C in temperature will lead to a possible loss 4-5 million tonnes of wheat grain. Losses are expected to be small for rainy season crops while for crops like pea, mustard, potato, tomato, onion, fruit crops like apple, etc., losses can be significantly high. Nearly 700 million rural people in India for their livelihood depend directly on sectors like agriculture, forestry, dairy and fisheries which are highly sensitive to climate change. Under changing climate scenario, the food security of the nation might be under threat. So to reduce the forthcoming negative impacts of climate change, we have to focus on adaptation research, capacity building, development of necessary infrastructural facilities and change our policies. Development of stress tolerant genotypes and alternate land use systems to ensure production on sustainable basis is essential. We need to provide reliable weather forecasts, agro-advisory systems to farmers, early warning systems for flood, drought, cyclones, etc. Provision of financial incentives for resource conservation and efficient use of inputs particularly that of water conservation technologies is essential.

76. ADAPTATION TO CLIMATE CHANGE : FLOOD TOLERANT RICE FOR ENHANCING AND STABILIZING RICE PRODUCTIVITY IN SOUTH ASIA

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Rice is a food security crop of India, Bangladesh and Nepal. About 16 million ha rice area in these countries is prone to flash flood. Out of this approximately 7.4 million ha rice area in India, 1.6 million ha in Bangladesh and 50000 ha in Nepal encounter frequent flash. International Rice Research Institute, in collaboration with institutions from USA, India and Bangladesh identified a submergence tolerance gene, *SUB1*, from one of the rice land races, FR13A, from India. This gene was transferred to 5 rice mega varieties, i.e. Swarna, Samba Mahsuri, IR64, CR1009 and BR11 from South Asia using marker assisted backcross (MAB) breeding approach. These mega rice varieties are widely cultivated by the farmers because of their high yield and good grain quality. They cover almost 12.5 million ha area in India, Bangladesh and Nepal. However, these varieties are susceptible to flash floods. They can not tolerate more than 4 days of submergence. Now an improved mega rice variety with *SUB1* gene is exactly same as its original version in most of the characteristics except for tolerance to submergence. Varieties with *SUB1* gene can tolerate 14 to 17 days of submergence. Under flash flood condition Sub1 lines offer a yield advantage of 1 to 2 tons per ha as compared to other rice varieties. Swarna-Sub1 was released in India in record time in June 2009 and Swarna-Sub1 and BR11-Sub1 were released in Bangladesh in March 2010 for commercial cultivation. Other Sub1 lines are expected to be released for

large scale cultivation in India, Bangladesh and Nepal by the end of 2010. Due to their exceptional performance at farmers' fields under flooded condition and strong support from national system, these varieties are spreading at unprecedented speed. During 2010 wet season Swarna-Sub1 has reached >100000 farmers in India and Swarna-Sub1 and BR11-Sub1 to > 25000 farmers in Bangladesh. Swarna-Sub1 is expected to reach > 5 million farmers in India, Bangladesh and Nepal by 2014. These Sub1 lines offer great promise to enhance and stabilize rice producity in flood-prone areas.

77. GREEN SUPER RICE (GSR) TECHNOLOGY: A HOLISTIC APPROACH TO TACKLE RICE PRODUCTION CONSTRAINTS OF BANGLADESH

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Demand projection for the rice production in Bangladesh by 2025 is estimated to be about 51 % of the current production levels. To meet the enormous challenge especially under recent global climatic changes, Bangladesh needs to take up concrete steps towards securing its food requirement in the first place. Amongst the viable technological options in hand, GSR technology comprising inbreds and hybrids that requires lesser chemical inputs while giving stable and sustainable yields under varied agro-climatic conditions including biotic and abiotic stresses appears to be promising. GSR technology at CAAS & IRRI involving introgression breeding through generation of massive genetic introgressions from as many as 500 donors (includes BR24) representing rice genetic diversity into elite adaptable 54 recurrent parents (which also includes BR11).These advance backcross populations are screened in BC_2F_2 onwards against different biotic and abiotic stress conditions of a given ecosystem and the promising transgressive segregants are selected after confirmation in subsequent generations are then carefully used for designed QTL pyramiding (DQP) steps using molecular markers converging from different donors. These second and third generation pyramiding lines (PDLs) are then confirmed and fixed in the target ecosystem/sites. This strategy has allowed us to identify a few promising drought tolerant PDLs with high NPK use efficiency already in IR64 background and is currently in Bangladesh for its testing and release. Besides PDLs in IR64 background for salinity tolerance is being currently tested in Satkira. Further, as many as 169 GSR hybrids and 106 inbreds have been tested in Bangladesh with BRAC and BRRI collaboration. Initial results are highly encouraging to find 54 GSR hybrids to have significant yield advantage over the inbreds, out of which 20 of them showed >15% yield advantage. GSR inbreds (22) tested in two locations showed WTR1 and Hua565 to have yield advantage of 36.7% and 14.7% over the inbred checks. These GSR varieties have been entered into national trials. GSR trials conducted by BRRI and BRAC to identify and upscale potential GSR products suitable for Bangladesh. The second and third generation of GSR products will be developed in Bangladeshi popular varietal backgrounds i.e. BR11 especially keeping the grain quality features intact with higher market value. These GSR products will be combined with specific crop management packages along with IPM and SSNM strategies to maximize the outputs while reducing the costly chemical inputs. GSR project will be delivering products along with trained scientific manpower that will not only make Bangladesh self sufficient in its rice production but also shape the livelihoods of millions of resource poor rice farmers.

78. DESIGNING CLIMATE CHANGE-READY RICE: SALT AND SUBMERGENCE TOLERANT RICE

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Rice yields in climate change-vulnerable areas will be increasingly affected by drought, flooding, and salinity. Recent scientific discoveries and advances, particularly in genetics and genomics, have opened up new opportunities to reduce the impact of these stresses. IRRI's experience in delivering technologies to farmers in favorable areas and the developments in rice genomics during the last five years indicate that climate change-ready rice started to be available to farmers. Genes or quantitative trait loci (QTL) conferring tolerance of salinity have been accurately mapped and markers developed. The identification of the precise gene underlying tolerance has enabled the detailed manipulation of this gene in marker-assisted selection (MAS) schemes. The transfer of submergence tolerance via the *Sub1* gene into widely grown "mega" varieties illustrates the tremendous promise of this approach. A major QTL, designated *Saltol*, mapped on chromosome 1, explains most of the variation in salt uptake. Recently *Saltol* was fine-mapped and a marker-assisted breeding (MAB) system is being developed for its incorporation into popular varieties. Multiple abiotic stresses often coexist in rice-growing areas, which require incorporation of several tolerance QTLs and genes. The strategy will involve pyramiding multiple tolerance genes, such as *Saltol* (salt) and *Sub1* (submergence) in the same recurrent parents to develop more resilient varieties for wider adaptation. This presentation will demonstrate the application of molecular marker technology from the laboratory to the farmers' field.

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