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IDENTIFICATION OF SALT TOLERANT RICE LINES AND DEVELOPMENT OF M_2 POPULATION THROUGH INDUCED MUTATION

M. M. Islam[1], S. N. Begum[1], M. M. Hasan Sohel[1], M. S. R. Khanom[1] and N. Hoque[1]

Abstract

A total of sixty rice germplasm were evaluated for salinity tolerance in hydroponic system at the seedling stage using modified IRRI standard protocol. Salinized and non-salinized set up were maintained at seedling stage. Phenotyping for salinity screening of the rice genotypes was done using saline water (EC = 12 dS/m). Germplasm were evaluated individually for salinity tolerance on 1-9 scale on the basis of seedling growth parameters following modified Standard Evaluation System (SES) of IRRI. At the seedling stage, 9 tolerant, 15 moderately tolerant, 10 highly susceptible and rest of the germplasm were found susceptible. On the basis of SES, and phenotypic performance, out of 60 rice germplasm, 24 were selected as salt tolerant. The selected 24 rice germplasms were screened for salinity tolerance at the reproductive stage at EC level 6-8 dS/m. Two strains (viz., Pokkali and PBRC-37) were found as salt tolerant and four varieties as moderately tolerant. Based on the screening at seedling stage, salt tolerant parental genotypes were identified and used for irradiation. Three salt tolerant rice varieties (viz., Pokkali, FL-378 and FL-478) were irradiated with different doses (250, 300 and 350 Gy) of gamma-rays and a total of 122 M_2 plants were selected from FL-378 and FL-478 based on short duration, plant height, and resistant/tolerant to diseases and insect-pests.

Key words: Rice, Salinity, Screening, Salinity tolerance, Induced mutation

Introduction

Salt stress, a consequence of the accumulation of soluble salts in the soil and/or water, is considered as the major soil problem both in coastal and in inland rice growing areas. Plant growth in these soils is adversely affected because of reduced water uptake, salt toxicity, and nutrient imbalances (Munns *et al.,* 2006). About 100 million ha of lands suited to rice production in South and Southeast Asia are still unused because of salinity and associated soil problems (Senadhira, 1994) and more than 25 million ha of rice lands are seriously affected by high salt stress.

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In Bangladesh, one million ha of rice lands are currently affected by salinity including 53% of the coastal area (Laisa *et al*., 2004) and further degradation will have detrimental consequences on food security due to limited land resources. Breeding efforts to exploit these areas have been hampered by the intricacy and coexistence of multiple abiotic stresses and the complexity of traits involved in tolerance of a particular stress (Ismail *et al.,* 2007).

The rice plant is one of the most suitable crops for saline soils, although it is considered moderately sensitive to salinity (Mori and Kinoshita, 1987). Rice responses to salinity, in varying degrees occur at all growth stages from germination to maturation (Neeraja *et al.,* 2007). Rice is generally susceptible to salinity during early seedling stage, flowering stage and reproductive stage. Salinity screening of rice is needed to observe salt tolerance in rice germplasm, mutants or varieties. IRRI developed such reliable screening technique where rice can be evaluated at the seedling and reproductive stages (Gregorio *et al.,* 1997). Salt tolerance is a quantitative trait, which is affected by environmental variation. Efforts are ongoing to develop salt tolerant varieties for the salt prone area, which recently culminated in the release of BRRI dhan 47 (Salam *et al.*, 2007). However, this variety still possesses few undesirable traits such as shattering. Farmers desire salt tolerant rice with better yield. Induced mutation has been extensively used for creating new genetic variation in crop plants. More than 2200 mutant varieties of different crops with improved agronomic traits have been developed and released to the farmers for cultivation worldwide (Maluszynski *et al.,* 2000). Mutation breeding is an easy and less laborious technique than conventional breeding methods in varietal development.

The objectives of the study were to screen rice germplasm for salinity at the seedling and reproductive stages, and develop salt tolerant rice varieties through induced mutations.

Materials and Methods

The experiment was carried out at the glasshouse and experimental field of Plant Breeding Division of Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh. A total of 60 rice germplasm (mutants, landraces, and exotic materials) were used for this study. All of these germplasm were collected from BINA, Mymensingh.

A. Rice germplasm screening for salinity tolerance: (Both seedling and reproductive stage)

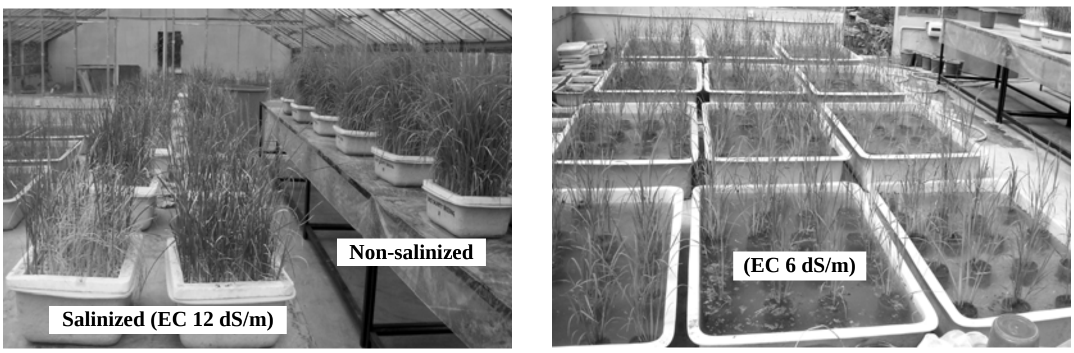
Selected 60 rice germplasms were evaluated for salinity tolerance in hydroponic system at the seedling stage using IRRI standard protocol (Gregorio *et al*., 1997). Nutrient solution was used in hydroponic system for screening salinity tolerance at the seedling stage. To prepare 360 L of nutrient solution, 450 ml of each macro-nutrient and 450 ml of micro-nutrient solutions was mixed with distilled water (dH_2O). p^H of the solution was measured by p^H meter. The nutrient solution was changed after every eight days with the newly proposed solution. The modified SES of IRRI was used to assess the visual symptoms of salt toxicity (Table 1). This scoring discriminates the tolerant, moderately tolerant and susceptible rice lines. Initial scoring was started at 15-day after salinization and final scoring was done at 21-day after salinization. Highly tolerant, tolerant, moderately tolerant, susceptible and highly susceptible were scored 1, 3, 5, 7 and 9, respectively (Gregorio *et al*., 1997)

Table 1. Modified IRRI Standard Evaluation System (SES) score based on the visual symptoms of saline injury at seedling stage of rice (*Oryza sativa* L.)

Score	Observation	Tolerance
1	Normal growth, no leaf symptoms	Highly tolerant
2	Nearly normal growth, but leaf tips or few leaves whitish and rolled	Tolerant
3	Growth severly retarded, most leaves rolled and few elongating	Moderately tolerant
4	Complete cessation of growth, most of the leaves dry and some plants dying	Susceptible
5	Almost all plants dead or dying	Highly susceptible

Selected twenty four rice germplasms were screened for salinity tolerance in sustained water bath at the reproductive stage using IRRI standard protocol (Gregorio *et al*., 1997). The evaluation was done at the glasshouse of BINA, Mymensingh.

The pre-germinated seeds (3/4 seeds pot^{-1}) of test genotypes were sown on the soil surface in soil filled pots, which were kept in the tray with water. After two weeks, the seedlings were thinned to two pot^{-1} and water level raised 1-2 cm above the soil surface. The water level was maintained daily and the plants were protected from insects and diseases. After 21 days, tap water was replaced with salinized water for salinized set up with EC 6 dS/m (Fig. 1).



a) Screening at seedling stage **b) Screening at reproductive stage stage**

Fig. 1. Screening of rice germplasm a) at seedling stage using hydroponic system (EC 12 dS/m) and b) at reproductive stage (EC 6 dS/m) using sustained water bath grown at BINA glasshouse

Data were scored for all the entries on flag leaf symptoms at flowering stage (Table 2). Rice yield and yield component data were also recorded from the reproductive stage in both normal and salinized conditions. Data were recorded on plant height (cm), days to flowering, days to maturity, number of effective tillers plant^{-1}, number of filled grains plant^{-1}, reduction of number of filled grains plant^{-1}, number of unfilled grains plant^{-1}, total dry mater (g), reduction of total dry matter (g), percent fertility and grain yield plant^{-1} (g). These were recorded following the standard evaluation system of IRRI (IRRI, 1997).

Table 2. Modified Standard Evaluation System (SES) of visual salt injury at reproductive stage

Score	Observation (Flag-leaf damage %)	Tolerance
1	No flag-leaf symptoms	Highly tolerant
3	1-10% damage	Tolerant
5	11-25% damage	Moderately tolerant
7	26-50% damage	Susceptible
9	More than 51% damage	Highly susceptible

B. Creation of variability through irradiation of seeds and generation advance

Based on the screening at seedling and reproductive stages, three salt tolerant parental genotypes (viz., Pokkali, FL-378 and FL-478) were identified. Seeds of each genotype were irradiated with different doses (250 Gy, 300 Gy and 350 Gy) of gamma-rays to develop salt tolerant high yielding lines/varieties. Five hundred seeds of each genotype were irradiated and raised in the seed beds along with their parents at BINA Head Quarter during the T. aman season, 2011. Thirty day old seedlings were transplanted in the field for growing M_1 populations. Plot size was 5.1 m × 3.8 m. A closer spacing 15 cm x 15 cm were maintained for hills and rows during transplantation. Data were recorded on germination percentage, seedling height, survival rate, days to maturity, plant type, shape and seed yield. The seeds of M_1 plants were harvested and kept each panicle separately in different packets. Subsequently, M_1 seeds were grown in plant progeny rows to get M_2 population and M_2 seeds were selected based on short duration, plant height, and resistant/tolerant to diseases and insect-pests.

Results and Discussion

A. Rice Germplasm Screening for Salinity Tolerance

A total of 60 rice germplasms (including landraces, exotic lines and HYVs) were evaluated for salinity tolerance in hydroponic system at the seedling stage. Out of 60 rice germplasms, 9 germplasms were selected as tolerant and 15 were moderately tolerant. On the other hand, 10 germplasms were highly susceptible and rest of the germplasms was susceptible. These 24 four rice genotypes were selected based on salt tolerance, high growth and better performance (Table 3). Islam *et al*. (2011) also observed wide variation among the 300 plants in phenotypes with the salinity stress of 12 dS/m EC from tolerant (score 3) to highly susceptible (score 9) using modified SES of IRRI standard protocol. Among the 300 plants, 93 were tolerant and 207 were sensitive.

Table 3. Performance of rice germplasm under salinized condition (EC 12 dS/m) grown in hydroponic system at the seedling stage

Name of the rice germplasms	SES scoring	Tolerance
PBSAL-613, PBSAL-614, PBSAL-655, PBSAL-730, STL-20, FL-378, FL-478, PBRC-37 and PBSAL-656	3	Tolerant
Horkuch, Ashfal, Nona Bokra, IR84645-308-2-1-B, IR63731-1-1-3-3-2, PBSAL-546, IR71829-3R-2B-1, IR72049-B-R-22-3-1-1, IR70023-4B-R-12-3-1, IR72580-B-24-3-3-3-2, Pokkali, IR84645-2-11-1-B, IR72593-B-18-2-2-2, IR72593-B-3-2-3-3 and IR77664-B-25-1-2-1-3-12-3	5	Moderately tolerant
Binadhan-7, STL-15, PBRC-83, PBRC-90, PBRC-110, PBSAL-731, PBRC-30, PBRC-56, PBRC-64, PBRC-67, PBRC-69, PBRC-82, PBRC-97, PBRC-132, IR77674-3B-8-2-214-4, IR84645-308-2-1-B, Kaliboro 139-2, Bara (Boro) Dhan, Bawoi Jhak, Jangliboro 581, Kaliboro 109-4, , Kalo Bhog, Dhol Kochuri, Charnock (DA6), Dhaliboro 105-2 and Latisail 11-117	7	Susceptible
Iratom-24, Binadhan-4, Kashrail, IR45427-2B-2-2B-1-1, IR68144-2B-2-2-3-3, IR72593-B-13-3-3-1, Binadhan-5, Binadhan-6, Chini Sagar and Kala Jira	9	Highly susceptible

Screening at reproductive stage

Twenty four rice germplasms were screened for salinity tolerance in sustained water bath at the reproductive stage. Two strains (viz., Pokkali and PBRC-37) were found as salt tolerant, four genotypes as moderately tolerant and others as susceptible at EC level 6 dS/m (Table 4). Salinity tolerance at each of these stages is associated with numerous physiological traits that need to be combined to attain higher levels of tolerance (Yeo and Flowers, 1986; Moradi and Ismail, 2007; Ismail *et al.*, 2007). More distinct varietal difference was observed at reproductive stage than that of vegetative and seedling stage (Akbar *et al.*, 1985; Mishra *et al.*, 1990).

Table 4. Performance of selected rice germplasms under salt stress (EC 6 dS/m) at reproductive stage

Name of the germplasm	Salinity tolerance
Pokkali and PBRC-37	Tolerant
STL-20, FL-378, FL-478, IR63731-1-1-3-3-2	Moderately tolerant
PBSAL-613, PBSAL-614, PBSAL-655, PBSAL-730, PBSAL-656 Horkuch, Ashfal, Bara Dhan, IR84645-308-2-1-B, PBSAL-546, IR71829-3R-2B-1, IR72049-B-R-22-3-1-1, IR70023-4B-R-12-3-1, IR72580-B-24-3-3-3-2, IR84645-2-11-1-B, IR72593-B-18-2-2-2, IR72593-B-3-2-3-3 and IR77664-B-25-1-2-1-3-12-3	Susceptible

B. Creation of variability and generation advance

Three salt tolerant rice genotypes (viz., Pokkali, FL-378 and FL-478) were irradiated with different doses (250, 300 and 350 Gy) of gamma-rays and grown for M_1 population. Panicle from each of the M_1 population has been harvested separately except Pokkali. Pokkali was damaged due to water logged condition. Subsequently M_1 seeds were grown in plant progeny rows to get M_2 population. Finally, a total of 115 mutant plants/lines of FL-378 and 7 plants/lines of FL-478 from M_2 population were selected based on short duration, plant height, and resistant/tolerant to diseases and insect-pests. The selected M_2 plants/lines will be evaluated for salt tolerance at seedling and reproductive stages. It needs further study to determine the level of salinity tolerance.

Conclusion

Out of 60 rice germplasm, 9 germplasm were found as salt tolerant and 15 were moderately tolerant in hydroponic system at the seedling stage based on modified SES (1-9 scale) score. For salinity tolerance screening in sustained water bath at the reproductive stage, two strains (viz., Pokkali and PBRC-37) were found as salt tolerant, four genotypes as moderately tolerant and others as susceptible at EC level 6 dS/m. A total of 122 M_2 seeds of FL-378 and FL-478 were harvested based on short duration, plant height, disease and insect infestation. The selected M_2 plants/lines will be evaluated for salt tolerance at seedling and reproductive stages. It needs further study to determine the level of salinity tolerance.

References

Akbar, M., Khush, G. S. and Hillerislambers, D. 1985. Genetics of Salt Tolerance. International Rice Genetics, IRRI, Philippines, pp. 399-409.

Gregorio, G. B., Senadhira, D. and Mendoza, R. D. 1997. Screening rice for salinity tolerance. IRRI Discussion Paper Series No. 22. International Rice Research Institute, Manila, Philippines, pp. 1-30.

Islam, M. R., Salam, M. A., Hassan, L., Collard, B. C. Y., Singh, R. K. and Gregorio, G. B. 2011. QTL mapping for salinity tolerance at seedling stage in rice. Emir. J. Food Agric., 23 (2): 137-146.

Ismail, A. M., Heuer, S., Thomson, S. M. J. and Wissuwa, M. 2007. Genetic and genomic approaches to develop rice germplasm for problem soils. Bangladesh J. Prog. Sci. & Tech., 5(1): 14-19.

IRRI (International Rice Research Institute). 1997. Rice Almanac. IRRI-WARDA-CIAT, Los Baños, Laguna, Philippines. p. 181.

Laisa, A. L., Seraj, Z. I., Elahi, C. M. F., Das, K. C., Biswas, K., Islam, M. R., Salam, M. A. and Gomosta, A. R. 2004. Genetic variation in microsatellite DNA, physiology and morphology of coastal saline rice (*Oryza sativa* L.) landraces of Bangladesh. Plant Soil, 263: 213-228.

Maluszynski, M., Nichterlein, K., Van Zanten, L. and Ahloowalia, B.S. 2000.Officially released mutunt varieties. The FAO/International Atomic Energy Agency Database, IAEA, Vienna, Austria. Mut. Breed. Rev., No. 12. pp. 1-84.

Mishra, B., Akbar, M. and Sashu, D. V. 1990. Genetic studies on salinity tolerance in rice towards better productivity in salt-affected soils. *In:* Rice Research Seminar. 12 July 1990. IRRI, Los Baños, Laguna. p. 25.

Moradi, F. and Ismail, A. M. 2007. Responses of photosynthesis, chlorophyll fluorescence and ROS scavenging system to salt stress during seedling and reproductive stages in rice. Ann. Bot. 99: 1161-1173.

Mori, I. Koh and Kinoshita, T. 1987. Salt tolerance of rice callus clones. Rice Genet. Newsl., 4: 112-113.

Munns, R., James, R. A. and Läuchli, A. 2006. Approaches to increasing the salt tolerance of wheat and other cereals. J. Exp. Bot. 57: 1025-1043.

Neeraja, C., Maghirang, R. R., Pamplona, A., Heuer, S., Collard, B., Septiningsih, E. G. Vergara, D. Sanchez, Xu, K., Ismail, A. and Mackill, D. 2007. A marker-assisted backcross approach for developing submergence-tolerant rice cultivars. Theor. Appl. Genet., 12: 40-45

Salam, M. A., Rahman, M. A. Bhuiyan, M. A. R. Uddin, K., Sarker, M. R. A., Yasmeen, R. and Rahman, M.S. 2007. BRRI dhan47: a salt tolerant variety for the boro season. Int. Rice Res. Newsl., 32: 42-43.

Senadhira, D. 1994. Rice and problem soils in South and Southeast Asia. IRRI Discussion Paper Series No. 4. Manila (Philippines): International Rice Research Institute, Manila, Philippines, pp. 1-2.

Yeo, A. R. and Flowers, T. J. 1986. Salinity resistance in rice (*Oryza sativa* L.) and a pyramiding approach to breeding varieties for saline soils. Aust. J. Plant Physiol., 13: 161-173.

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PHOTOSYNTHESIS, CHLOROPHYLL STABILITY AND GRAIN GROWTH OF AROMATIC RICE GENOTYPES UNDER HIGH TEMPERATURE STRESS

M. Tariqul Islam

Abstract

A pot experiment was conducted with five aromatic rice genotypes *viz*., BRRI dhan34, Ukunimadhu, RM-100-16, KD_5-18-150 and Kalizira in plant growth chamber to assess the effects of high temperature at different growth stages on photosynthetic rate, chlorophyll stability and grain growth. Three temperature treatments *viz*., Ambient, 35°C at tillering stage and 35°C at booting stage were imposed and continued for 7 days. Plants of all the genotypes were also kept at 30°C from flowering to maturity for grain growth studies. Photosynthetic rate, grain yield and harvest index decreased but leaf conductance and transpiration rate increased with high temperature (35°C) at both of tillering and booting stages. Total dry matter plant^{-1} was the lowest with the temperature (35°C) at booting stage. The highest grain dry weight, chlorophyll content and photosynthetic rate were found in the mutant KD_5-18-150 during grain growth period. Plant height and number of effective tillers plant^{-1} were not affected by the temperature treatments. The genotype KD_5-18-150 showed higher grain yield, total dry matter plant^{-1} and harvest index under temperature stress.

Key words : High temperature, Photosynthesis, Chlorophyll stability, Growth stage, Grain growth, Aromatic rice

Introduction

There is a major consensus among scientists, except for some minor disagreements, that climate is changing and air temperature is raising due to increasing concentration of CO_2 and other atmospheric greenhouse gases (Weiss *et al*., 2003; Kerr, 2005; IPCC, 2007). Rice (*Oryza sativa* L.) is one of the major cereals produced worldwide and constitutes the staple food of more than half of the world population (FAO, 2007). The rise in atmospheric temperature causes detrimental effects on growth, yield and quality of the rice crop by affecting its phenology, physiology and yield components (Singh, 2001; Sheehy, *et al*., 2005; Peng *et al*., 2004).

The sensitivity of rice to high temperature varies with growth phase, an increase in day/night temperature, and genotype (Yoshida, 1981; Singh, 2001; Peng *et al*., 2004). The unusual rise in atmospheric temperature during different growth phases differentially affects rice growth and productivity. The quantitative assessment of such type of climatic

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variability on aromatic rice productivity is very limited. Keeping in view, the significance of climatic variability on the growth and yield of the rice crop, an experiment was conducted using five aromatic rice mutants/varieties to assess the effects of high temperature stress at different growth stages on photosynthetic rate, chlorophyll stability and grain growth.

Materials and Methods

The pot experiment was conducted with five aromatic rice genotypes *viz*., BRRI dhan34, Ukunimadhu, RM-100-16, KD_5-18-150 and Kalizira in controlled plant growth chamber at the Bangladesh Institute of Nuclear Agriculture, Mymensingh. The experiment was laid out in a completely randomized design with three replications. Thirty-days old seedlings were transplanted in plastic pots on 8 August 2012. Each pot contained 8 kg of soils (Silty loam; organic matter 1.05%, total N 0.07%, available P 14.3 ppm, exchangeable K 0.25 meq. per 100g soil, available S 13.2 and soil pH 6.67). Soils were fertilized with urea 1.36 g pot^{-1}, TSP 0.80 g pot^{-1}, MP 0.52 g pot^{-1} corresponding to urea 170 kg ha^{-1}, TSP 135 kg ha^{-1} and MP 65 kg ha^{-1}, respectively. All TSP, MP and one- third of the urea were applied as basal dose. The remaining two-thirds of the urea were applied in two equal splits in each pot at 30 and 50 days after transplanting. Cultural practices were done whenever necessary. Three temperature treatments *viz.,* Ambient (mean≈24^{o}C), 35^{o}C at maximum tillering and 35^{o}C at booting stage were imposed and continued for 7 days. Plants of all the genotypes were also kept at 30^{o}C and ambient during grain growth period. Data on plant height, number of effective tillers plant^{-1}, grain yield and total dry matter plant^{-1} were recorded. Photosynthetic rate, transpiration rate and leaf conductance were measured using Portable Photosynthesis system (Model: Li-6400XT) and chlorophyll content of flag leaves were measured using SPAD meter (Model: SPAD 502). Grain dry weight, chlorophyll content (SPAD reading) and photosynthetic rate of flag leaf were measured at 3 days interval from fertilization to maturity.

Results and Discussion

Result revealed that photosynthetic rate decreased but leaf conductance and transpiration rate increased with high temperature (35^{o}C) at both of tillering and booting stages (Table 1). Reduced photosynthetic rate under high temperature stress is in conformity with Izumi *et al*. (2004). BRRI dhan34 had the highest photosynthetic rate followed by Ukunimadhu and KD_5-18-150. RM-100-16 showed the highest leaf conductance and transpiration rate. Plant height and effective tillers plant^{-1} were not affected by the temperature treatments (Table 2). Grain yield and harvest index decreased similarly with the temperature (35^{o}C) at tillering and booting stages. High temperature reduced grain weight by a reduction in grain growth rate in the early or middle stages of

Table 1. Photosynthetic rate, conductance and transpiration rate of fine grain aromatic rice genotypes under high temperature (35^{o}C) at tillering and booting stages

Treatments	Pn	Cond	Tr
Temperature			
Ambient (T_0)	24.3a	0.30b	3.88c
35^{o}C at tillering stage (T_1)	17.5b	0.39a	5.36b
35^{o}C at booting stage (T_2)	14.2c	0.39a	5.93a
Genotypes			
BRRI dhan34 (V_1)	21.74a	0.37b	4.48c
Ukunimadhu (V_2)	19.11b	0.38b	5.16b
RM-100-16 (V_3)	17.2c	0.42a	5.99a
KD_5-18-150 (V_4)	18.5b	0.33c	4.46c
Kalizira (V_5)	17.0c	0.35bc	5.19b

Values having common letter(s) in a column do not differ significantly at 5% level of probability as per DMRT.

Where, Pn = Photosynthetic rate ($\mu molCO_2m^{-2}s^{-1}$)
Cond = Conductance ($molH_2Om^{-2}s^{-1}$)
Tr = Transpiration rate ($molH_2Om^{-2}s^{-1}$)

grain filling. The results are in conformity of those of Morita *et al.* (2005) and Singh *et al.* (2010) who observed reduced grain weight due to high temperature stress in rice. Total dry matter plant^{-1} was the lowest with the temperature (35^{o}C) at booting stage. KD_5-18-150 showed higher grain yield and total dry matter plant^{-1} tillering stage under temperature stress. This mutant also showed the highest grain yield and total dry matter plant^{-1} at ambient condition (Table 2). The highest harvest index (22.3%) was found in Ukunimadhu (V_2) under stress temperature but Kalizira (V_5) produced the highest harvest index (33.5%) under ambient temperature (T_0). Results showed that grain dry weight and photosynthetic rate decreased but chlorophyll content of flag leaf was unaffected with temperature treatments (Table 3). The highest grain dry weight, chlorophyll content and photosynthetic rate were found in the mutant KD_5-18-150. Kalizira showed medium grain dry weight and photosynthetic rate. BRRI dhan34 had better grain dry weight and lower photosynthetic rate. The lowest grain dry weight was found in Ukunimadhu. The mutant RM-100-16 had lower grain dry weight and photosynthetic rate. Chorophyll contents of all the genotypes were identical except in KD_5-18-150. Higher grain dry matter accumulation in KD_5-18-150 was due to its better chlorophyll stability and photosynthetic rate during grain growth period.

Table 2. Yield and yield attributes of fine grain aromatic rice under high temperature (35^{o}C) at booting and grain filling stages

Treatments	Plant height (cm)	Effective tillers plant^{-1}	Grain yield plant^{-1} (g)	Total dry matter plant^{-1} (g)	Harvest Index (%)
Temperature					
Ambient (T_0)	140	8.2	11.9a	45a	26.4a
35^{o}C at tillering stage (T_1)	142	8.4	7.6b	37c	20.5b
35^{o}C at booting & grain filling stages (T_2)	137	7.4	7.2b	40b	18.0c
Varieties					
BRRI dhan34 (V_1)	149	7.7.6ab	8.4b	39b	21.5
Ukunimadhu (V_2)	138	8.5ab	8.7b	39b	22.3
RM-100-16 (V_3)	144	7.7.8ab	8.3b	38bc	21.4
KD_5-18-150 (V_4)	138	8.7a	11.3a	51a	22.1
Kalizira (V_5)	144	7.2b	7.8b	36c	21.6
Interaction					
T_0 V_1	153	8.4 abc	9.5cd	43d	22.0bc
T_0 V_2	135	9.0ab	6.4fg	45cd	14.2efg
T_0 V_3	151	6.0c	13.2b	44cd	30.0a
T_0 V_4	147	9.0ab	17.9a	59a	30.3a
T_0 V_5	156	8.1abc	12.4b	37fg	33.5a
T_1 V_1	151	8.1 abc	8.1ef	44cd	18.4cde
T_1 V_2	135	8.1abc	9.2cde	31h	29.6a
T_1 V_3	138	10.3a	4.0i	22i	18.1def
T_1 V_4	141	8.4 abc	10.3c	54b	19.0cd
T_1 V_5	147	6.6bc	6.6fg	34gh	19.4cd
T_2 V_1	143	6.6bc	7.7ef	31h	24.8b
T_2 V_2	143	8.4abc	10.3c	42de	24.5b
T_2 V_3	146	6.7bc	7.8def	48c	16.2def
T_2 V_4	130	8.4abc	5.8gh	42de	13.8fg
T_2 V_5	130	6.6bc	4.4hi	38ef	11.5gh

Values having common letter(s) in a column do not differ significantly at 5% level of probability as per DMRT.

Table 3. Effect of temperature on grain dry weight, chlorophyll content and photosynthetic rate of flag leaf during grain filling period of aromatic rice genotypes

Treatments	Grain dry weight grain^{-1} (g)	SPAD reading (Chlorophyll)	Photosynthetic rate ($\mu molCO_2m^{-2}S^{-1}$)
Ambient	7.95a	38.35	21.13a
30^0C	7.44b	37.66	13.79b
Genotypes			
BRRI dhan34	7.80b	36.37b	16.68d
Ukunimadhu	6.40e	37.81b	17.15c
RM-100-16	6.61d	38.02b	16.71d
KD_5-18-150	10.86a	39.89a	19.46a
Kalizira	6.83c	37.95b	17.29b
Days			
0	1.44g	39.86a	21.70a
4	2.20f	39.60a	19.77b
8	5.79e	38.56ab	18.93c
12	8.54d	38.24ab	17.84d
16	9.66c	37.74ab	17.10e
20	10.55b	37.03b	15.34f
24	11.70a	36.83b	14.74g
28	11.69a	36.21b	14.25h

Values having common letter(s) in a column do not differ significantly at 5% level of probability as per DMRT.

Conclusion

High temperature (35^{o}C) at both of tillering and booting stages decreased photosynthetic rate, grain yield and harvest index of aromatic rice genotypes. However, higher grain dry matter accumulation in KD_5-18-150 was due to its better chlorophyll stability and photosynthetic rate during grain growth period.

References

FAO. International year of rice, 2007. Available at: <http://www.fao.org/rice2004/en/speeches.htm>. Accessed on: 5 Feb. 2007.

IPCC. Climate change, 2007. The physical science basis: contribution of working group I to the fourth assessment report of the intergovernmental panel on climate change. Cambridge: Cambridge University Press.

Izumi, O., Saitoh. K. and Kuroda, T. 2004. Effects of rising temperature on growth, yield and dry-matter production of rice grown in the paddy field. *In:* New directions for a diverse planet: Proceedings for the 4th International Crop Science Congress, Fischer T *et al.,* eds. Brisbane, Australia, 26 September 1 October 2004.

Kerr, R. A. 2005. Millennium's hottest decade retains its title, for now. Science, 307: 828-829.

Morita, S., Yonemaru, J. and Takanashi, J. 2005. Grain growth and endosperm cell size under high night temperatures in rice *Oryza sativa* L. Ann Bot. 95(4): 695-701.

Peng, S., Huang, J., Sheehy, J. E., Laza, R. C., Visperas, R. M., Zhong, X., Centeno, C. S., Khush, G. S. and Cassman, K. G. 2004. Rice yields decline with higher night temperature from global warming. Proc. Natl. Acad. Sci. USA, 101(27): 9971-9975.

Sheehy, J. E., Elmido, A., Centeno, G. and Pablico P. 2005. Searching for new plants for climate change. J. Agric. Meteorol. 60: 463-468.

Singh, S., Aggarwal, P. K. and Yadav, R. N. 2010. Growth and yield response of rice under heat stress during vegetative, reproductive and ripening growth phages. International Rice Research Note (0117-4185), IRRI, Los Baños, Philippines.

Singh, S. 2001. Growth, yield and biochemical response of rice genotypes to low light and high temperature-humidity stress. Oryza, 37(1): 35-38.

Weiss, A., Hays, C. J. and Won, J. 2003. Assessing winter wheat responses to climate change scenarios: a simulation study in the U. S. Great Plains. Climatic Change, 58:119-147.

Yoshida, S. 1981. Fundamentals of rice crop science. *In:* Climate and rice. Los Baños (Philippines): International Rice Research Institute, pp. 87-88.

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BINAMOOG-8: GREEN SHINY COLOR MUTANT VARIETY OF MUNGBEAN AND HOPE FOR THE FARMER

S. N. Begum[1] and M. M. Islam[1]

ABSTRACT

Mutations were induced in dry seeds of mugbean line MB-149 (early maturing, large seeded, high yielding and susceptible to MYMV) using gamma rays as mutagen with a view to develop early maturing, large seeded, high yielding and disease resistant variety (s) of mungbean. Mutant variety of mungbean (Binamoog-8) was registered by the National Seed Board (NSB) of Bangladesh in 2010. The true breeding line MBM-07 (Binamung-8) derived from 400 Gy of gamma ray showed to be promising for several desirable characters like earliness, bold seeded and dwarf plant type and also tolerant to mungbean yellow mosaic virus (MYMV). The distinct features of the selected mutant MBM-07 (Binamoog-8) are medium plant height (35-40 cm), early maturing (64-67 days), deep green leaf color, shiny green seed coat color, 22-23% protein content, average seed yield of 1.80 tons ha^{-1} and tolerant to MYMV. Farmers in Bangladesh widely adopted and integrated Binamoog-8 variety in their cropping system.

Key words: Mungbean, Induced mutations, Mutant lines, Yield

Introduction

Mungbean (*Vigna radiata* (L.) Wilczek), one of the important legume crops, is widely cultivated in the tropics and subtropics for human consumption, animal feed as well as cover crop. Mungbean is prized among the pulse spices as its seeds are high in essential diatary protien, easily digested and low production of flatulence when consumed as food (Lakhanpaul and Bhat, 2000). Induced mutations have been used to generate genetic variability and have been successfully utilized to improve yield (Rao and Siddiq, 1977). Physical and chemical mutagenic agents cause genes to mutate at rates above the spontaneous base line, thus producing a range of novel traits and broadening of the genetic diversity of plants (Lagoda, 2007). Mungbean contained some kinds of natural antioxidants, such as flavonoids have specific properties of health benefits like enhancing plasma antioxidant activity and preventing cardiovascular diseases (Ali *et al.*, 2010). The selection and development of mutants into recommended varieties for the farmers have been successfully made in many countries (Chow and Loo, 1988; Bahl and Gupta, 1983). Many farmers were able to grow themselves out of poverty by incorporating this extra high value mungbean varieties into their cereal rotations. Incorporation of early maturing

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mungbean varieties in crop rotation, resulted increased farmers' net income, enhanced nutritional diets and enriched soil health. The objective of this experiment was to develop a short duration, high yielding and MYMV disease resistant mungbean variety so that it can fit in the cropping pattern to increase farmer's income.

Materials and Methods

A mutation breeding program was undertaken at Bangladesh Institute of Nuclear Agriculture (BINA) in 2001 with a view to develop early maturing, large seeded, high yielding and disease tolerant variety (s) of mungbean. The Binamoog-8 (true breeding line, MBM-07) was developed through irradiation of dry seeds of MB-149 line (high yielding, bold seeded but susceptible to yellow mosaic virus) followed by selection of desirable mutants from the irradiated population. The MB-149 was a cross between Binamoog-1 and an exotic photoneutral yellow mosaic resistant mungbean line V-2011, collected from AVRDC. Seeds of MB-149 were irradiated with three doses of gamma rays viz., 300, 400 and 500 Gy for creating variability. M_1 population was grown at BINA farm, Mymensingh during Kharif-1 season, 2001. Preliminary selection of mutants and their breeding behaviour were observed in M_2, $M_{3,}$ M_4 and M_5 generation during 2002-2005. The true breeding line MBM-07 derived from the applied dose 400 Gy of gamma ray showed promising for several desirable characters like earliness, higher seed yield, dwarf plant type, photoneutral and also tolerance to MYMV. The selected mutant MBM-07 was then tested along with the check varieties (Binamoog-5 and BARI Mung-5) in kharif-1 season for preliminary yield trial (PYT) and advanced yield trials (AYT) during 2005-06 and 2006-07, respectively. Zonal yield trials (ZYT) were conducted during kharif-1 season of 2007-08 in different agro-ecological zones of Bangladesh to observe their field performance. Seeds were sown in RCB design with three replications. Unit plot size of PYT, AYT and ZYT were 2 m × 3 m, 4 m × 2.5 and 4 m × 5 m, respectively. Row to row and plant to plant distances were 40 cm and 10 cm, respectively. Recommended fertilizer doses were applied. Data on days to maturity, plant height, pods plant^{-1}, pod length, seeds pod^{-1}, and seed yield plot^{-1} were recorded from five randomly selected plants from each plot. Plot seed yield was converted to kg ha^{-1}. Mean values were used for statistical analyses following Gomez and Gomez (1984).

Finally, on the basis of better performance for desired characters, the mutant MBM-07 was also evaluated in the on-station and farmers' field at Barisal, Jhalokathi, Rajshahi, Natore, Ishurdi, Magura, Dinajpur and Jamalpur during the kharif-1 season of 2008-09.

Results and Discussion

The promising mutants MBM-07 and MBM-292 along with two checks were put under comparative yield trials at different locations in the country. The average days to maturity, pods plant^{-1} and seed yield (kg ha^{-1}) of farmers field trials in six locations are presented in Table 1a. The mutant MBM-07 was found to be the earliest than other mutants and checks (Binamoog-5 and BARI Mung-5). The mutant MBM-07 produced the highest seed yield of 1770 kg ha^{-1}.

Table 1a. Average days to maturity, pods plant^{-1} and seed yield (kg ha^{-1}) from farmers' field trials of 6 locations

Mutants/checks	Days to maturity	Pods plant^{-1} (no.)	Seed yield (kg ha^{-1})
MBM-07	64	20.6	1770
MBM-292	75	18.1	1445
Binamoog-5 (check)	77	15.7	1406
BARI Mung-5 (check)	70	12.6	1351

Mutants MBM-07 and MBM-292 along with two checks (Binamoog-5 and BARI Mung-5) were grown at different environments for screening against yellow mosaic (MYM) during 2006, 2007, 2008 and 2009. Severity and disease reaction are shown in Table 1b. The mutants MBM-07 and MBM-292 showed moderately resistant (MR) against MYM in most of the locations. Reddy (2009) observed a mutant showing very minor leaf symptom for YMV and without any pod symptom in M_3M_1 generation. The mutant was purified by growing up to M_3M_6 generations. All the mutant plants showed very minor leaf symptoms but no symptoms in the pod. The pods and seeds were normal and also gave normal yield as compared to highly resistant check.

Table 1b. Mean of yellow mosaic virus severity (0-9 scale) of mungbean grown at different locations during 2006, 2007, 2008 and 2009

YEAR	2006			2007			2008			2009			
Variety \ Location	Mymensingh	Ishurdi	Dinajpur	Mymensingh	Ishurdi	Magura	Mymensingh	Ishurdi	Magura	Mymensingh	Ishurdi	Mean Severity	Disease reaction
Yellow mosaic													
MBM-07	3.3	0.8	2.5	2.9	1.0	1.7	0.8	1.0	0.9	1.0	0.7	1.51	MR
MBM-292	3.5	0.9	2.4	1.4	1.1	1.1	1.3	1.0	1.1	2.1	1.1	1.55	MR
Binamoog-5	3.8	1.3	2.9	2.1	1.0	1.3	1.2	1.1	1.2	2.0	1.2	1.74	MR
BARI Mung-5	3.4	2.5	2.5	2.9	1.3	1.4	1.1	1.0	1.1	2.1	1.1	1.85	MR

The mutant lines along with checks were evaluated at different agro-ecological zones for their yield performance. Results of PYT, AYT, ZYT and farmers' field trials are presented in Table 2 to Table 9. Significant variations were observed among the mutant lines and checks for almost all the parameters under study in all trials.

The PYTs were conducted with 11 mutant lines along with two checks at two locations viz., Ishurdi and Magura during 2005-06. The mutant MBM-07 produced the highest seed yield and was the earliest maturing than all other mutants and check varieties. The mutant MBM-07 along with some other mutants was selected for further evaluation in AYT.

Table 2. Seed yield and other yield contributing traits of some selected summer mungbean mutants

Mutants/checks	Plant height (cm)	Days to maturity	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	100-seed weight (g)	Seed yield (kg ha^{-1})
MBM-07	42 d*	64 f	21 a	8.3b	4.0	1578 a
MBM-18	57 b	70 cd	18 ab	8.0c	4.8	1190 bc
MBM-21	51 c	70 cd	15 c	6.7g	5.4	1273 b
MBM-22	52 c	68 e	19 ab	6.4h	5.2	1244 b
MBM-38	53 c	69 d	18 b	7.6d	5.4	802 e
MBM-43	50 c	72 ab	18 b	7.3e	4.3	1261 b
MBM-45	51 c	67 e	18 ab	7.4e	4.0	1231 bc
MBM-46	50 c	72 a	14 c	8.5a	4.9	986 d
MBM-48	50 c	70 cd	14 c	7.1f	4.2	1060 c
MBM-49	52 c	71 bc	13 c	6.3h	3.5	1043 c
MBM-292	50 c	69 d	14 c	8.0c	3.8	1166 bc
Binamoog-5 (check)	61 a	73 a	19 ab	7.6d	4.2	1267 b

Values having same letter(s) in a column do not differ significantly at 5% level of probability.

The AYTs were carried out with 4 mutants along with 2 checks at four locations (Mymensingh, Magura, Chapainowabgonj and Thakurgaon) during kharif-1 season of 2006-07. MBM-07 produced the highest number of pods plant^{-1} and was found to be matured earlier than the other mutants and checks. In respect of seed yield, MBM-07 produced the highest seed yield (1586 kg ha^{-1}) followed by MBM-43 (1291 kg ha^{-1}) and Binamoog-5 (1253 kg ha^{-1}). Finally, two mutants MBM-07 and MBM-292 were selected for early maturity and higher seed yield. Statistical analysis of different characters (average of four locations) of the mutants and checks are presented in the Table 3.

Table 3. Performance of four elite mutants along with two check varieties grown at four locations during 2006-07

Mutants/checks	Plant height (cm)	Pods plant^{-1} (no.)	Pod length (cm)	Seeds pod^{-1} (no.)	Days to maturity	Seed yield (kg ha^{-1})
MBM-07	45.2b	19a	7.9ab	11.5	65d	1586a
MBM-21	50.2a	16b	7.5ab	11.0	71c	1253b
MBM-43	51.6a	17 b	7.3ab	11.3	75b	1291b
MBM-292	52.5a	16.b	7.9ab	11.2	70c	1170c
Binamoog-5 (check)	50.3a	18.a	8.5a	11.3	77a	1253b
BARI Mung-5 (check)	37.7c	15bc	8.3a	11.1	74b	1103d

Values having same letter(s) in a column do not differ significantly at 5% level of probability.

The results of ZYTs conducted during the kharif-1 season, 2007-08 of individual locations and means over 4 locations for all the characters are presented in Table 4. MBM–07 had the highest pod length than all other mutants and checks. Among the

Table 4. Performance of two elite lines along with the check varieties grown at four locations during 2007-08

Mutants/checks	Plant height (cm)	Pods plant^{-1} (no.)	Pod length (cm)	Seeds pod^{-1} (no.)	Days to maturity	Seed yield (kg ha^{-1})
Ishurdi						
MBM-07	39.7bc	15.8b	8.06	11.6	64d	1700a
MBM-292	41.4ab	18.9a	8.70	10.9	71c	1250c
Binamoog-5 (check)	44.1a	15.0b	8.13	11.7	76a	1400b
BARI Mung-5 (check)	36.3c	14.5b	8.03	10.9	74b	1255c
Magura						
MBM-07	55.8b	17.4b	8.90	11.4	65d	1665a
MBM-292	46.3c	19.5a	7.73	11.2	71c	1260c
Binamoog-5 (check)	62.5a	15.8c	8.76	11.1	77a	1335b
BARI Mung-5 (check)	40.5d	17.8b	8.53	9.9	74b	1230c
Rajshahi						
MBM-07	33.9	15.1a	8.26a	10.8	65c	1570a
MBM-292	31.1	13.2b	6.10b	8.0	70c	1200b
Binamoog-5 (check)	32.3	12.7b	7.80a	8.2	77a	1125c
BARI Mung-5 (check)	31.3	10.6c	7.76a	7.8	71b	1110c
Dinajpur						
MBM-07	38.4	15.0a	8.13b	11.0	66d	1585a
MBM-292	42.2	14.0a	6.93c	10.0	70c	1180b
Binamoog-5 (check)	38.7	9.3b	8.43a	10.3	79a	1200b
BARI mung-5 (check)	35.2	8.6b	8.00b	9.3	76b	1080c
Average of 4 locations						
MBM-07	42.0ab	15.8a	8.34a	11.2a	65d	1630a
MBM-292	40.2b	16.4a	7.36b	10.0ab	71c	1223b
Binamoog-5 (check)	44.4a	13.2b	8.28ab	10.3ab	77a	1265b
BARI Mung-5 (check)	35.8c	12.8bb	8.08ab	9.5b	74b	1169c

Values having same letter(s) in a column do not differ significantly at 5% level of probability.

mutants and checks, MBM-07 produced the highest number of pods plant^{-1}, pod length and seeds pod^{-1}. In respect of seed yield, MBM-07 produced the highest seed yield of 1580 kg ha^{-1} followed by the check variety Binamoog-5. Many researchers reported that seed yield is strongly dependent on pod size, Pods plant^{-1} and Seeds pod^{-1} (Ahmed *et al*., 1998; Dutta and Mondal, 1998; Sadi, 2004). MBM-07 also matured earlier than other genotypes.

A total of three mutant lines along with two check varieties (Binamoog-4 and BARI Mung-5) were put into ZYT at Mymensingh, Magura and Ishurdi during winter season of 2007-08 and results are presented in Table 5. From average of three locations, it showed that MBM-07 was found to be matured 4 to 6 days earlier than BARI Mung-5 and Binamoog-4. Mutant MBM-07 produced shorter plant height than both the checks. MBM-07 gave almost equal number of pods plant^{-1} like Binamoog-4. In respect of seed yield, MBM-292 produced the highest seed yield of 1265 kg ha^{-1} followed by MBM07 (1207 kg ha^{-1}) and Binamoog-4 (1173 kg ha^{-1}). As a photoneutral mutant, MBM-07 also produced higher seed yield in winter season.

On-station and farmers' field trials were conducted with two check varieties (Binamoog-5 and BARI Mung-5) at eight locations (Barisal, Jhalokathi Rajshahi, Natore, Ishurdi, Magura, Dinajpur and Jamalpur) during 2008-2009. The mutant MBM-07 was found to be matured earlier and produced the highest seed yield in on-station and farmers' management trials at all the locations (Tables 6 and Table 7). At on-station trials, on an average, MBM-07 took 65 days to mature and seed yield was 1880 kg ha^{-1}. Similar trend of seed yield produced by the entry was found as in farmers' management trials (Table 8). The comparative seed yield under on-stations and farmers' field trials is shown in Table 9. Average seed yield of MBM-07 was 1809 kg ha^{-1}.

Table 5. Performance of three lines along with the check varieties grown at Mymensingh and Ishurdi during 2007-08

Mutants/checks	Days to maturity	Plant height (cm)	pods plant^{-1} (no.)	Pod length (cm)	Seeds pod^{-1} (no.)	Seed yield (kg ha^{-1})
Mymensingh						
MBM-07	66c	46.21b	13.93 b	8.27	12.27a	1390a
MBM-292	73b	47.00b	18.87 a	9.23	11.40ab	1419a
MBM-346	78a	58.40a	13.13 b	9.30	12.80a	780c
Binamoog-4 (check)	70b	47.33b	18.33 a	7.97	10.87b	1183b
BARI Mung-5 (check)	72b	46.87b	13.00 b	8.77	11.67ab	907c
Magura						
MBM-07	65b	57.87c	16.67a	8.27	11.40a	1095b
MBM-292	72a	64.07b	15.11a	9.57	11.20a	1167a
MBM-346	70a	64.27b	13.47b	9.17	11.80a	865c
Binamoog-4 (check)	69a	74.33a	15.07a	8.20	11.60a	990c
BARI Mung-5 (check)	70a	65.47b	14.60ab	9.07	9.93b	727c

Table 5 Continued

Mutants/checks	Days to maturity	Plant height (cm)	Pods plant^{-1} (no.)	Pod length (cm)	Seeds pod^{-1} (no.)	Seed yield (kg ha^{-1})
Ishurdi						
MBM-07	64b	39.27c	18.47ab	8.23	12.33	1137bc
MBM-292	71a	42.33bc	19.80a	9.13	12.00	1208b
MBM-346	71a	52.47a	13.33c	8.07	11.53	987c
Binamoog-4 (check)	69ab	46.80b	19.67a	7.80	11.13	1345a
BARI Mung-5 (check)	70a	42.00bc	17.00ab	8.13	12.07	977c
Average of 3 locations						
MBM-07	65b	49.22bc	16.36a	8.26	12.00	1207ab
MBM-292	72a	51.13b	17.93a	9.31	11.53	1265a
MBM-346	73a	58.38a	13.31c	8.84	12.04	877b
Binamoog-4 (check)	69a	56.16a	17.69a	7.99	11.20	1173ab
BARI Mung-5 (check)	71ab	51.44b	14.86ab	8.66	11.22	870b

Values having same letter(s) in a column do not differ significantly at 5% level of probability.

Table 6. Days to maturity of MBM-07 and checks grown at on-station field trials during 2008-09

Mutants/ checks	Days to maturity								Average of 8 locations
	Barisal	Jhalokathi	Rajshahi	Natore	Ishurdi	Magura	Dinajpur	Jamalpur	
MBM-07	64c	64c	65b	65c	65c	67b	66b	64c	65c
Binamoog-5	72a	73a	73a	80a	78a	80a	78a	79a	77a
BARI Mung-5	68b	69b	70ab	72b	73b	70b	70b	71b	70b

Values having same letter(s) in a column do not differ significantly at 5% level of probability.

Table 7. Seed yield (kg ha^{-1}) of MBM-07 and checks grown at on-station trials during 2008-09

Genotypes/variety	Seed yield (kg ha^{-1})								Average seed yield (kg ha^{-1})
	Barisal	Jhalokathi	Rajshahi	Natore	Ishurdi	Magura	Dinajpur	Jamalpur	
MBM-07	1745a	1685a	1885a	1980a	2190a	1980a	1695a	1885a	1880a
Binamoog-5 (check)	1337b	1300b	1570b	1575b	1890b	1680b	1330b	1795b	1560b
BARI Mung-5 (check)	1260c	1290b	1350c	1550b	1585c	1470c	1340b	1650c	1437c

Values having same letter(s) in a column do not differ significantly at 5% level of probability.

Table 8. Seed yield (kg ha^{-1}) of MBM-07 and checks grown at farmers' field during 2008-09

Mutants/checks	Seed yield (kg ha^{-1})								Average seed yield (kg ha^{-1})
	Barisal	Jhalokathi	Rajshahi	Natore	Ishurdi	Magura	Dinajpur	Jamalpur	
MBM-07	1485a	1580a	1825a	1877a	2000a	1873a	1422a	1849a	1739a
Binamoog-5 (check)	1185b	1236b	1528b	1507b	1800b	1653b	1287b	1751b	1493b
BARI Mung-5 (check)	1108b	1156b	1192c	1428b	1500c	1410c	1297b	1555c	1331c

Values having same letter(s) in a column do not differ significantly at 5% level of probability.

Table 9. Comparative seed yield (kg ha^{-1}) of MBM-07 and checks grown at on-station and farmer's field during 2008-09

Mutants/checks	Seed yield (kg ha^{-1})		Average seed yield (kg ha^{-1})
	Research management (kg ha^{-1})	Farmers' management (kg ha^{-1})	
MBM-07	1880a	1739a	1809a
Binamoog-5 (check)	1560b	1493b	1527b
BARI Mung-5 (check)	1437c	1331c	1384c

Values having same letter(s) in a column do not differ significantly at 5% level of probability.

Conclusion

The mutant line MBM-7 was registered as Binamoog-8 for commercial cultivation in Bangladesh. Seeds of new registered mutant variety Binamoog-8 are medium, ovoid in shape and green shiny in color. After registration of improved mungbean variety Binamoog-8, the area, yield and production are in increasing trends.

References

Ahmed, Z. U., Begum, S. N. and Begum, S. 1998. Two new mungbean varieties-Binamoog-3 and Binamoog-4 for cultivation in Bangladesh. Bangladesh J. Nuclear Agric., 14: 53-58.

Ali, M. A., Abbas, G., Mohy-ud-Din, Q., Ullah, K., and Aslam, M. 2010. Response of mungbean (*Vigna radiata*) to phosphatic fertilizer under arid climate. J. Animal Plant Sci., 20: 83-86.

Bahl, J. R. and Gupta, P. K. 1983. Promising mutants in mungbean, (*Vigna radiata* (L.) Wilczek). Plant Breeding Abstr., 53(2): 165.

Chow, K. H. and Loo, E. H. 1988. Mutation Breeding in mungbean by using EMS, In: Mungbean proceedings of the Second International Symposium, Nov. 16-20, Bangkok, pp. 178-185.

Dutta, R. K. and Mondal, M. M. A. 1998. Evaluation of lentil genotypes in relation to growth characteristics, assilmilate distribution and yield potential. LENS Newsl., 25: 51-55.

Gomez, K. A. and Gomez, A. A. 1984. Statistical Procedures for Agricultural Research. John Wiley and Sons, USA.

Lagoda, P. J. L. 2007. Effects of mutagenic agents on the DNA sequence in plants. Plant Breed. Genet. Newsl., 19: pp. 13-14.

Lakhanpaul, S. S. C. and Bhat, K. V. 2000. Random Amplified Polymorphic DNA (RAPD) analysis in Indian Mungbean (*Vigna radiata* (L.) Wilczek) cultivars. Genetica. 109: 227-234.

Rao, G. M. and Siddiq, E. A. 1977. Induced variations for yield and its components in rice. Indian J. Genet. Plant Breed. 37(1): 12-21.

Reddy, K.S. 2009. A new mutant for yellow mosaic virus resistance in Mungbean (*Vigna radiata* (L.) Wilczek) variety SML-668 by Recurrent Gamma-ray Irradiation. *In:* Q. Y. Shu (ed.), Induced plant mutations in the Genomics Era. Food and Agriculture Organization of the United Nations, Rome, pp. 361-362.

Sadi, M. M. 2004. Comparative performance of mungbean genotypes in relation to yield and yield components. MS Thesis, submitted to the Dept. of Crop Botany, Bangladesh Agricultural University, Mymensingh, Bangladesh. p. 43.

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COMPARATIVE STUDY ON TOXIC METAL CONTAMINATION IN BALU RIVER WATER ADJACENT TO DHAKA–NARAYANGONJ–DEMRA

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Abstract

An extensive study was carried out in the Balu river water during the year of 2011-2012 with a view to evaluate the water quality regarding toxic metal contamination. A total of 72 surface water samples were collected from four different locations adjacent to the Balu river area of Dhaka-Narayangonj-Demra, during wet (July to September 2011) and dry season (November to January 2011-12). To determine the spatial distribution and seasonal variation of toxic metals (Pb, Cr, Ni, Cd and Zn), detailed, laboratory analysis was performed in the Soil Science Division of Bangladesh Institute of Nuclear Agriculture (BINA). Among the different locations, the maximum concentration of Pb, Cr, Ni, Cd and Zn was observed at Termuni area as; 0.10, 0.096, 0.263, 0.118 and 1.31mgL^{-1}, respectively. Considering locations and seasons, the highest concentration of toxic heavy metals was found at Termuni area during the dry season as; Pb (0.13 mgL^{-1}), Cr (0.11 mgL^{-1}), Ni (0.30 mgL^{-1}), Cd (0.161 mgL^{-1}) and Zn (1.772). The minimum concentration of Pb, Cr and Zn was noted at Demra area during the wet season as; 0.04, 0.048 and 0.697 mgL^{-1}, respectively. The Cd and Ni concentration was observed as; 0.025 and 0.133 mgL^{-1} at Nagarpara area. The present study reveals that concentration of Pb, Cr, Ni and Cd exceeded the standard level of drinking, irrigation, aquaculture and surface water set up by WHO, GOB, USEPA, DOE and FWPCA for the dry season.

Key words: Balu river, Locations, Water quality, Heavy metals

Introduction

Water is becoming an increasing scarce resource for agriculture. Wherever good quality water is limited, marginal quality water like sewage and other waste water is used to supplement irrigation needs, particularly in the peri-urban zones. River plays a major role in assimilating or carrying off industrial and municipal waste water, manure discharges and run off from agricultural fields, roadways and streets, which are responsible for river pollution (Stroomberg *et al*., 1995; Word and Elliot, 1995). Among the polluted areas of Bangladesh, the worst problems are in the area besides the river Balu where the most significance source of pollution appears to be from different industries in

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the Dhaka city area. Although waste water is an important source of plant nutrients, and helps in improving crop yields, it has likely adverse impact on human and soil health, which warrants constant monitoring. Most of the industries have no effluent treatment plant (ETP) and recycle plant in Dhaka city. As a result heavy metal pollution occurs in Balu river. Every year in monsoon, most of the crop fields are flooded by the river. During winter, the river water as well as waste water are extensively pumped for irrigation. So it occurs to contaminate toxic elements from water to food chain through soil and field crops.

About 80% of the diseases in developing countries are related to contaminated water, resulting death toll about 10 million per year. Excessive uptake of metals by plants may produce toxicity in human nutrition, causing acute and chronic diseases. For instance, Cd and Zn can lead to acute gastrointestinal and respiratory damages and acute heart, brain and kidney damages. High concentrations of heavy metals in soil can negatively affect crop growth as these metals interfere with metabolic functions in plants including physiological and biochemical processes, inhibition of photosynthesis, and respiration and degeneration of main cell organelles, leading to death of plants (Garbisu and Alkorta, 2001; Schmidt, 2003; Schwartz *et al*., 2003). Considering the above facts, the present study was conducted to assess toxic metals contamination of Balu river water during wet and dry season. Seasonal variation of toxic metals in Balu river was also evaluated.

Materials and Methods

The study area was Balu river, Dhaka–Narayangonj–Demra. Balu river located 23°43′51′′ (23.7308º) north latitude and 90º30′5′′ (90.5014º) east longitude. Seventy two water samples were collected (including 3 replications) from different locations during July 2011 to January 2012. For the river Balu, samples were taken from 4 locations namely- Termuni, Itakhola, Nagarpara and Demra Bridge to cover the maximum pollution areas due to industrial activities, municipal sewage sludge and urban runoff including agricultural activities. All samplings were performed through water sampler using country boat. Water samples were kept in clean plastic containers. All the bottles full of samples, after proper marking and labeling, were placed in the icebox to avoid direct sunlight and thus, the samples were transferred to laboratory and were kept in the refrigerator at 4^0C till analysis.

For analysis of the toxic metal, the water samples from the source points were also collected and immediately filtered with ADVANTEC 0.2 μm size sterile syringe filter and transferred into acid-cleaned 50 mL polypropylene bottles. One mL of ultra pure nitric acid was added in each polypropylene bottle to achieve a pH of ~1 (Cenci and Martin, 2004). Toxic metals (Cd, Cr, Zn, Ni and Pb) of the water samples were determined by the AAS method (Model-Perkin Elmer Analyst 800) by using the software Winlab 32 TM Changing Technique after digesting the samples with concentrated HNO_3 in the laboratory of Bangladesh Institute of Nuclear Agriculture (BINA).

Results and Discussion

Concentration of lead (Pb) in Balu river water

The Pb concentration in Balu river water significantly varied due to different locations and seasons. It ranged from 0.04 to 0.07 mgL^{-1} during wet season (i.e. July-September 2011) whereas in dry season it varied from 0.08 to 0.13 mgL^{-1} (Table 1). Among the different locations, the maximum Pb mean value was found at Termuni area (0.10 mgL^{-1}) and the minimum mean value of 0.065 mgL^{-1} was noted from the water sample at Nagarpara area. Research findings from several scientists showed the variation of Pb concentration in river water, which was 0.336 ppm (Sultana, 2005), 0.002 ppm (Mokaddes, 2008) and 0.0046 ppm (Tareq, 2010). Considering both the locations and seasons, the highest Pb concentration was noted at Termuni area during the dry season (0.13 mgL^{-1}) and the minimum value was noted at Demra area during the wet season (0.04 mgL^{-1}) shown in Fig. 1. Pandey *et al.* (2010) stated that the highest concentration of Pb was recorded during the winter season.

Table 1. Pb (mgL^{-1}) concentration in Balu river water (0-50 cm) at different location and seasons during 2011-2012

Seasons	Termuni	Itakhola	Nagarpara	Demra	Mean (season)
Wet season	0.07e	0.05f	0.05g	0.04h	0.05
Dry season	0.13a	0.11c	0.08d	0.12b	0.11
Mean (Location)	0.10	0.08	0.06	0.08	

Note: i. Mean followed by same letter (s) is not significantly differs at 5% level of probability. Capital letters were used for the mean variation for locations and seasons; small letters were used for the interaction mean of Season × Location

ii. Wet season indicates the average value of three months: July to September 2011 and Dry season indicates the average value of three months: November to January 2011-12.

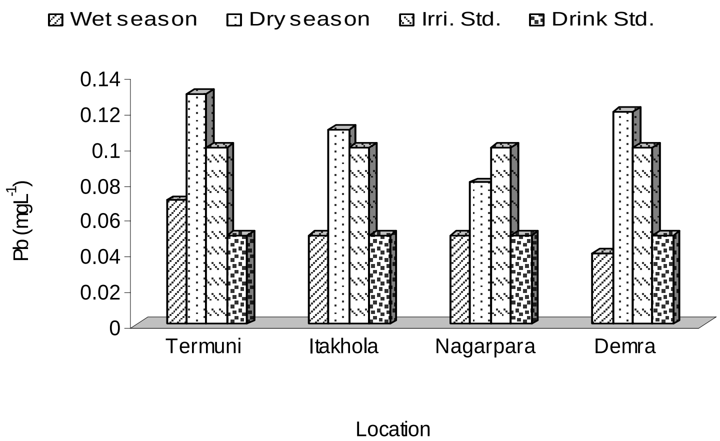

Fig. 1. Average Pb in Balu river water at different locations and seasons during 2011-12

Concentration of chromium (Cr)

Chromium (Cr) concentration of the Balu river water significantly varied due to different locations and seasons (Table 2). During the wet season (i.e. July-September 2011), the mean concentration of Cr in surface water ranged from 0.04 to 0.08 mgL^{-1} whereas in dry season, the mean concentration of Cr in Balu river water increased up to 0.11mgL^{-1}. Among the different locations, the maximum average chromium concentration in Balu river water was found at Termuni area (0.096 mgL^{-1}) and the minimum average concentration was noted from the water sample at Demra (0.052 mgL^{-1}). Concentration of Cr in the river Karnaphuli was 0.06 mgL^{-1} and in the river Halda it was 0.01 mgL^{-1} as reported by Bashar *et al.* (2007) and Dixit and Tiwari (2008) found maximum concentration of this metal of 0.2 in Shahpura lake of Bhopal, India. Considering both location and season, the Cr concentration in Balu river water along with irrigation and drinking standard was showed in Fig. 2. From the figure it was noted that the maximum concentration was found at Termuni area (0.11 mgL^{-1}) during dry season and the minimum was at Demra (0.048 mgL^{-1}) during the wet season. Pandey *et al.* (2010) stated that the highest concentration of Cr was recorded during the winter season in India. Kar *et al.* (2008) from West Bengal, India, noted that overall seasonal variation was significant for Cr. The mean concentration of Cr (0.02 mgL^{-1}).

Table 2. Cr (mgL^{-1}) concentration in Balu river water (0-50 cm) at different locations and seasons during 2011-2012

Locations/seasons	Termuni	Itakhola	Nagarpara	Demra	Mean (season)
Wet season	0.083c	0.062d	0.051f	0.048g	0.061B
Dry season	0.110a	0.095b	0.096b	0.056e	0.089A
Mean (Location)	0.096A	0.079B	0.073BC	0.052C	

Note: i. Mean followed by same letter (s) is not significantly differs at 5% level of probability. Capital letters were used for the mean variation for locations and seasons; small letters were used for the interaction mean of Season × Location

ii. Wet season indicates the average value of three months: July to September 2011 and Dry season indicates the average value of three months: November to January 2011-12.

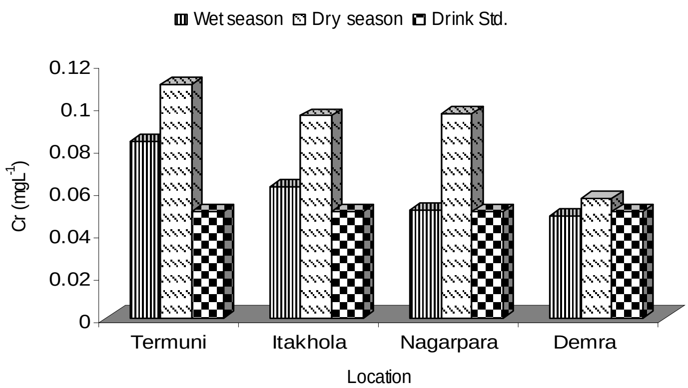

Fig. 2. Average Cr in Balu river water at different locations and seasons during 2011-12

exhibited their maximum value during the winter season. Mohiuddin *et al.* (2010) Buriganga River, Bangladesh, stated that the concentration of total chromium in water samples exceeded the toxicity reference values in both the seasons.

Concentration of Nickel (Ni)

Like other toxic metals, Ni concentration of the Balu river water significantly varied due to different locations and seasons (Table 3). During the wet season (i.e July-September 2011) the Ni concentration of the Balu river water ranged from 0.133 to 0.227 mgL^{-1} but it varied from 0.19 to 0.30 mgL^{-1} during dry season (November 2011 to January 2012). Among the four different locations, the concentration of Ni significantly differed and the highest mean value of 0.263 mgL^{-1} was found at Trimohoni area and the minimum mean concentration was observed as 0.162 mgL^{-1} in the water sample collected from Nagarpara area. Considering both location and season the maximum Ni concentration of 0.300 mgL^{-1} was located at Termuni area during dry season and the minimum value of 0.133 mgL^{-1} was found at Nagarpara area during wet season. According to US EPA (1999), the water containing less than 0.052 µg mL^{-1} Cr concentration can safely be used as irrigation water (Fig. 3). On the other hand, the guideline value of Ni for drinking water is 0.07 mgL^{-1} (WHO, 2008).

Table 3. Ni (mgL^{-1}) concentration in Balu river water (0-50 cm) at different locations and seasons during 2011-2012

Locations/seasons	Termuni	Itakhola	Nagarpara	Demra	Mean (season)
Wet season	0.227c	0.177ef	0.133g	0.143g	0.170
Dry season	0.300a	0.250b	0.190de	0.207cd	0.237
Mean (Location)	0.263	0.213	0.162	0.175	

Note: i. Mean followed by same letter (s) is not significantly differs at 5% level of probability. Capital letters were used for the mean variation for locations and seasons; small letters were used for the interaction mean of Season × Location

ii. Wet season indicates the average value of three months: July to September 2011 and Dry season indicates the average value of three months: November to January 2011-12.

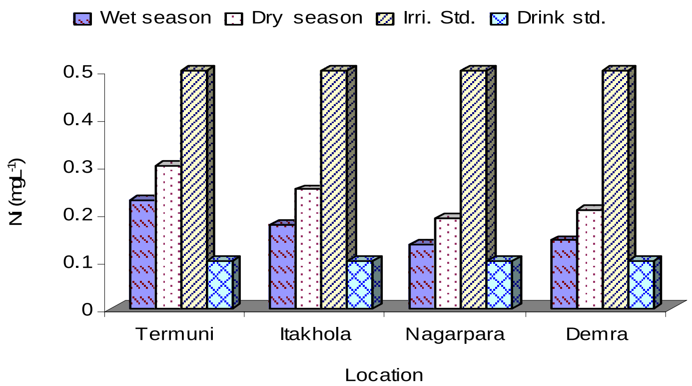

Fig. 3. Average Ni in Balu river water at different locations and seasons during 2011-12

Concentration of Cadmium (Cd)

From the Table 4, it was observed that Cd concentration of the Balu river water significantly varied and from the month of July–Sept' 2011 the mean Cd concentration ranged from 0.03 to 0.08 mgL^{-1}, whereas it varied from 0.08 to 0.16 mgL^{-1} during dry season (Nov' 11 to Jan' 12). Among the different locations, the maximum average Cd concentration was found at Termuni area (0.118 mgL^{-1}), which was also statistically different with the value of other locations. The minimum average Cd concentration was noted from the water sample at Nagarpara (0.0545 mgL^{-1}). The interaction effect of different locations and seasons was significantly influenced on the concentration of Cd in the Balu river water (Fig. 4). Mohiuddin *et al.* (2010) stated that the lower level of Cd was recorded during summer than in winter season. Mohuya *et al.* (2010) reported that the mean concentration of Cd in the Gulshan-Baridhara lake water was 0.083 and 0.018 mgL^{-1} during the summer and monsoon, respectively. Discharge from electro-plating units and zinc smelters are the main sources of Cd concentration in water. (Varshney, 1983). Metalic and plastic pipes can also contribute Cd in water (WHO, 1972). High content of Cd in the water might be due to discharge from the small electroplating industries in the catchments of the river and also from the surface drain pipe or tank pipe connected to Balu river.

Table 4. Cd (mgL^{-1}) concentration in Balu river water (0-50 cm) at different locations and seasons during 2011-2012

Locations/seasons	Termuni	Itakhola	Nagarpara	Demra	Mean (season)
Wet season	0.075e	0.047g	0.025h	0.054f	0.050
Dry season	0.161a	0.110b	0.084d	0.089c	0.111
Mean (Location)	0.118	0.078	0.054	0.071	

Note: i. Mean followed by same letter (s) is not significantly differs at 5% level of probability. Capital letters were used for the mean variation for locations and seasons; small letters were used for the interaction mean of Season × Location

ii. Wet season indicates the average value of three months: July to September 2011 and Dry season indicates the average value of three months: November to January 2011-12.

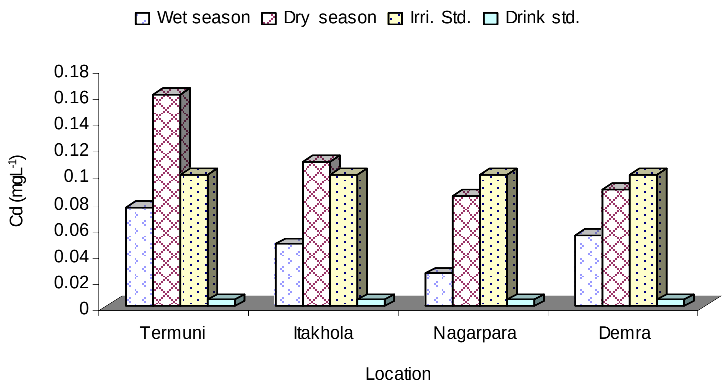

Fig. 4. Average Cd in Balu river water at different locations and seasons during 2011-12

Concentration of Zinc (Zn)

Like other metals, the concentration of Zn in Balu river water significantly varied and the concentration ranged from 0.663 to 1.772 mgL^{-1} during the wet season but during the winter, it gradually increased up to 1.772 mgL^{-1} (Table 5). Among the different locations, the maximum average Zn concentration was noted as 1.31 mgL^{-1} at Termuni area and the minimum average concentration was noted as 1.059 mgL^{-1} from the water sample at Demra area. Considering both locations and seasons, the maximum Zn concentration was found at Termuni area (1.772 mgL^{-1}) during dry season and the minimum value was noted at Demra (0.697 mgL^{-1}) during wet season (Fig. 5). Concentration of Zn in the Karasu Greek region was 440-530 as μgL^{-1} as reported by Yalcin *et al.* (2008). Borghei and Asghari (2005) found that waste water of Albourz industrial city, which contained some ions like Zn. So, it affected on growth of agricultural product and plant. They also found the range of Zn 0.005-5.5 mgL^{-1} unit in various wastewater samples. From the results it could be clearly stated that the concentrations of studied pollutants were higher during the dry season, particularly in the month of November to January, when the rainfall was comparatively low. But during the wet season the values were in generally low and fall within various standard levels.

Table 5. Zn (mgL^{-1}) concentration in Balu river water (0-50 cm) at different locations and seasons during the year, 2011-2012

Locations/seasons	Termuni	Itakhola	Nagarpara	Demra	Mean (season)
Wet season	0.849c	0.749cd	0.753cd	0.697cd	0.761
Dry season	1.772a	1.653a	1.482b	1.422b	1.582
Mean (Location)	1.310	1.201	1.118	1.059	

Note: i. Mean followed by same letter (s) is not significantly differs at 5% level of probability. Capital letters were used for the mean variation for locations and seasons; small letters were used for the interaction mean of Season × Location

ii. Wet season indicates the average value of three months: July to September' 2011 and Dry season indicates the average value of three months: November to January' 2011-12.

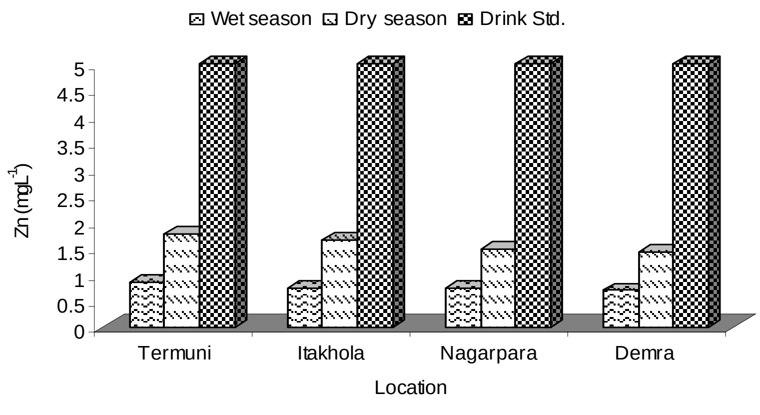

Fig. 5. Average Zn in Balu river water at different locations and seasons during 2011-12

Table 1. Standard value for irrigation water on heavy metal and other water quality parameters

Toxic Metal	Irrigation Standard
Lead (Pb)	0.5 μg mL^{-1}
Nickel (Ni)	0.5 μg mL^{-1}
Chromium (Cr)	1.0 μg mL^{-1}
Cadmium (Cd)	0.10 μg mL^{-1}
Zinc (Zn)	10 ppm

Note: Approved by NEQS - National Environmental Quality Standard

Table 2. Drinking water quality standards

Parameters (mg/l)	USEPA (2003)	WHO (1993)	Bangladesh (GOB, 1997)
Cd	0.005	0.003	0.005
Cr	0.10	0.05	0.05
Ni	0.10	0.02	0.1
Pb	0.015	0.01	0.10

Conclusion

It may be concluded that Balu river water contained acceptable amount of Zn whereas the concentration of Pb, Cr, Cd and Ni exceeded the recommended limit for drinking water, irrigation water and for aquaculture. Therefore, it is hazardous for human health, crops and aquaculture. From the results of the experiment it can be clearly stated that the concentrations of studied pollutants were higher during the dry season, particularly in the month of November to January, when the rainfall was comparatively low or absent. Conversely, during the wet season, the values were generally low and fall within various standard levels. The excess toxic metal load of river water may be due to the discharge of industrial effluents and municipal wastes, geology of river bed and catchments' area.

References

Bashar, M. A., Ullah, S. M., Waidbacher, H. G. and Ullah, B. 2007. Heavy metals in the water of some Chittagong region river systems. J. Asiat. Soc. Bangladesh. Sci. 33(1): 57-68.

Borghei, S. M. and Asghari, S. 2005. Environmental study on discharged wastewater of Albourz industrial city. Iranian J. Pub. Health, 34(1): 62-68.

Cenci, R. M. and Martin, J. M. 2004. Concentration and fate of trace metals in Mekong River Delta. Sci. Total Environ., 332(1-3): 167-182.

Dixit, S. and Tiwari, S. 2008. Impact assessment of heavy metal pollution of Shahpura Lake, Bhopal, India. Int. J. Environ. Res., 2(1): 37-42.

Garbisu, C. and Alkorta, I. 2001. Phytoextraction: A cost effective plant-based technology for the removal of metals from the environment. Biores. Technol., 77(3): 229-236.

Government of Bangladesh (GOB). 1997 Water Quality Standards of Bangladesh, Ministry of Water Resource, Bangladesh Gazzet.

Kar, D., Sur, P., Mandal, S. K., Saha, T. and Kole, R. K. 2008. Assessment of heavy metal pollution in surface water, Int. J. Environ. Sci. Techn., 5(1): 119-124.

Mohiuddin, K. M., Zakir, H. M. Otomo, K., Sharmin, S. and Shikazono, N. 2010. Geochemical distribution of trace metal pollutants in water and sediments of downstream of an urban river. Inter. J. Environ. Sci. Tech., 7: 17-28.

Mohuya F. A., Bhuiyan, R.H. and Hoque, S. 2010. Heavy metal contamination in Gulshan-Baridhara lake, Dhaka. Dhaka University. J. Biol. Sci. 19(1): 53-61.

Mokaddes, M. A. 2008. Current status of river, lake and drain water contamination of Dhaka Metropolitan City in Bangladesh. M.S. Thesis, Dept. Environ. Sci. Bangladesh Agril. Univ., Mymensingh. pp. 1-115.

Pandey, J., Shubhashish, K and Pandey, R. 2010. Heavy metal contamination of Ganga river at Varanasi in relation to atmospheric deposition, Int. Society for Tropical Ecology. 51(2): 365-373.

Schmidt, U. 2003. Enhancing phytoremediation: The effect of chemical soil manipulation on mobility, plant accumulation, and leaching of heavy metals. J. Environ. Qua., 32: 1939-1954

Schwartz, C., Echevarria, G. and Morel, J. L. 2003. Phytoextraction of cadmium with *Thlaspi caerulescens*. Plant and Soil. 249(1): 27-35. doi: 10.1023/A:1022584220411

Stromberg, G. J., Freriks, I. L., Smedes, F. and Cofino, W. P. 1995. Quality Assurance in Environmental Monitoring, P. Quevauviller ed. VCH, Weinheim.

Sultana, N. 2005. Nutritent content and heavy metal contamination in some roadside soils and grasses of Dhaka city, Bangladesh. M. S. Thesis, Submited to the Department of Agricultural Chemistry, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Tareq, N. U. 2010. Current status of river, lake and drain water contamination of Dhaka Metropolitan city in Bangladesh- A follow up research. M. S. Thesis, Submitted to the Department of Environmental Science, Bangladesh Agricultural University, Mymensingh, Bangladesh.

US EPA (U. S. Environmental Protection Agency). 1999. Screening Level Ecological Risk Assessment Protocol. Appendix E: Toxicity Reference values U. S. EPA Region 6. Office of Solid waste.

US EPA (U. S. Environmental Protection Agency). 2003. Environment Report, www.epa.gov/air/urbanair/lead/what.html, accessed on 22nd November 2003.

Varshney C. K. (eds.) 1983. Water Pollution and Management. Willey Eastern Limited, New Delhi, India.

Word, A. D. and Elliot, W. J. 1995. In Environmental Hydrology. A. D. Ward and W. J. Elliot ends CRC press, Boca caton. p. 1.

WHO (World Health Organization) 1972. Health Hazards of Human Environment. WHO, Geneva. 1972.

WHO (World Health Organization). 1993. Evaluation of certain food additives and contaminants. Forty-first report of the join FAO/WHO expert committee on food additives. Geneva, WHO Technical report Series, no. 837.

WHO (World Health Organization). 2008. Guidelines for Drinking Water Quality. Third edition, p. 516.

Yalcin, M. G., Aydin, O. and Elhatip, H. 2008. Heavy metal contents and the water quality of Karasu Creek in Nigde, Turkey. Environ. Monit. Assess. 137(1/3): 169-178.

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EFFECT OF DATE OF SOWING ON THE YIELD AND YIELD CONTRIBUTING CHARACTERS OF CHICKPEA VARIETIES

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Abstract

A field experiment was carried out at the Bangladesh Institute of Nuclear Agriculture (BINA) sub-station farm, Ishurdi during the rabi season of 2007-'08 to find out the optimum date of sowing of chickpea varieties. The treatments of the experiment were; four sowing dates (November 1, November 15, December 1 and December 15) and three varieties (Binasola-4, Binasola-3 and Hyprosola). The results of four dates of sowing demonstrated that early sowing (November 1 and November 15) produced the highest number of branches plant^{-1}, pods plant^{-1}, seeds pod^{-1} and seed yield (1991-2085 kg ha^{-1}). Late sowing (December 1 and December 15) produced the shortest plant height, lowest number of branches and pods plant^{-1} and seeds pod^{-1}, smallest size of seed and lowest seed yield. Among the different varieties, Binasola-4 produced higher seed yield (2085 kg ha^{-1}) followed by Binasola-3 (2036 kg ha^{-1}) in November 15 sowing.

Key words: Sowing date, Chickpea, Seed yield

Introduction

Chickpea (*Cicer arietinum* L.) is one of the most important pulse crop grown in Bangladesh. It is one of the protein and other essential nutrient rich crop (Khan *et al*., 1997). It is popular in Bangladesh and it is called "Sola and boot" by majority of the people. Among the continents, Asia contributes about 90% to the worlds production of chickpea (Jodha and Rao, 1986). It is the third most important legume in the world (Van Rheenen, 1991). From the nutritional point of view, chickpea is, perhaps the best among the common pulses. Unfortunately, Bangladesh is facing a serious problem about pulse production for the last few years and the present situation is alarming. The indigenous production can cover only up to 9.86% of the total demand and the rest is being imported (BBS, 2005). The pulse crops get no preference and priority in the sowing schedule (Yadav, 1992). Dixit (1992) recorded the highest chickpea yield on 26 October sowing. Similarly, the highest seed yield was recorded by Arvandia and Patel (1988) under 21 November sowing. Late sowing shortens the growth period, induces maturity and reduces grain size and yield. In early sowing, high temperature and humidity often encourage excessive growth (Yadav, 1992). Therefore, the success of crop growth during dry season

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depends on timely sowing which has virtually a definite relationship with efficient utilization of residual soil moisture (Belvins, 1986). The late sown varieties subjects to lower temperature and get relatively shorter time span available for growth and development of the crop. An experiment was therefore, conducted to evaluate the effect of date of sowing on the yield and yield contributing characters of chickpea.

Materials and Methods

The experiment was conducted at the BINA sub-station farm, Ishurdi during November 2007 to April 2008 to find out the optimum sowing date of chickpea varieties. Treatments were; four sowing dates (November 1, November 15, December 1 and December 15) and three varieties (Binasola-4, Binasola-3 and Hyprosola). The experiment was laid out in a split plot design with three replications. The entire experimental field was divided into three blocks and each block was divided into four main plots and each main plot was divided into three sub plots. The total plots of the experiment were 36 (3 × 4 × 3). The size of each plot was 3 m × 4 m. The sowing date was placed in the main plots and the varieties were placed in the sub-plots. After making lay out of the experiment, the lands were fertilized. Chemical fertilizers were applied @ 25.0, 23.0, 28.0, 10.0, and 1.0 as N, P, K, S and Zn from urea, triple super phosphate, muriate of potash, gypsum and zinc sulphate ha^{-1}, respectively. The fertilizers were used in all the unit plots using Fertilizer Recommendation Guide (BARC, 2005). The full dose of N, P, K, S, and Zn were applied as basal at final land preparation. Seeds were sown on November 1, November 15, December 1 and December 15, 2007 @ 40 kg ha^{-1}. To avoid the contamination; seeds were treated with fungicide vitavax 200 @ 2 g kg^{-1} seed before sowing. The 50 cm apart furrows with 4 cm depth were made with hand tine for sowing seed. Healthy seeds were sown by hand as uniformly as possible in furrows. The seeds were covered with soil to have a good seed-soil contact. The cultural practice such as weeding was done two times i.e. 25 and 45 days after sowing. Thinning was done on the same date of first weeding to maintain plant to plant distance of 10 cm. A light irrigation was given immediately after sowing. To control pod borer, Ripcord at the rate of 10 ml/10 litre water and to control root rot disease fungicide, Ridomil MZ 72 at the rate of 25 g/10 litre water were sprayed two times at 60 and 75 days after sowing. Data on yield contributing characters were recorded from ten randomly selected plants. The yield was taken from whole plots and converted in kg ha^{-1}. Data were compiled and analyzed throught MSTAT computer package and the mean values were judged by DMRT.

Results and Discussion

All the plant characters were highly significant for sowing date and except seeds pod^{-1}, all other plant characters were found significant for variety (Table 1). The combined effect differed significantly for all the agronomic characters, except branches $plant^{-1}$, seeds pod^{-1} and 1000-seed weight (Table 2).

Highest seed yield (Table 1) was obtained in November 15 (2037 kg ha^{-1}) sowing which was identical with November 1 (2017 kg ha^{-1}). Among the varieties, Binasola-4 produced the highest seed yield (1669 kg ha^{-1}) followed by Binasola-3 (1658 kg ha^{-1}). However, Hyprosola produced lowest seed yield (1625 kg ha^{-1}). It also showed that yield performance of all the varieties were better in early sowing and the range of average yield was 1085-2085 kg ha^{-1} (Table 2). The highest seed yield (2085 kg ha^{-1}) was obtained in November 15 sowing from Binasola-4 and the second highest (2036 kg ha^{-1}) was from Binasola-3. In November 1 sowing, Hyprosola produced the third highest seed yield (2000 kg ha^{-1}). All the three varieties produced comparable yield on December 1 sowing (1452, 1435 and 1425 kg ha^{-1}, respectively) and sowing on December 15 produced the lowest seed yield (1085-1129 kg ha^{-1}) by all the varieties.

Table 1. Effects of date of sowing and cultivars on yield and yield contributing characters of chickpea

Treatments	Plant height (cm)	Branches plant^{-1} (no.)	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	1000-seed weight (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	H. I. (%)
Date of sowing:								
November 1	44.74 a	5.04 a	70.16 a	1.91 a	131.14 a	2017 a	3404 a	37.22 a
November 15	46.77 a	5.16 a	72.34 a	1.86 a	131.17 a	2037 a	3428 a	37.49 a
December 1	36.70 b	3.66 b	63.19 b	1.67 b	124.99 b	1437 b	2754 b	34.30 b
December 15	33.19 c	2.63 c	34.96 c	1.34 c	121.21 c	1111 c	2228 c	33.28 c
LSD $_{0.05}$	2.08	0.42	4.34	0.11	1.30	28.96	27.19	0.63
Variety:								
Binasola-4	40.89 a	4.23 a	60.22 b	1.71	122.63 b	1669 a	3015 a	35.43 b
Binasola-3	41.30 a	4.19 a	64.91 a	1.72	160.20 a	1658 a	3005 a	35.24 b
Hyprosola	38.86 b	3.95 b	55.38 c	1.66	98.56 c	1625 b	2840 b	36.06 a
LSD $_{0.05}$	0.83	0.21	1.51	NS	1.20	18.98	21.33	0.39
CV (%)	1.73	5.90	2.10	3.86	0.79	0.96	0.61	0.93

Means in a column followed by same letter are not significantly different at 5% level of significance by DMRT; LSD = Least Significant Difference; CV = Co-efficient of Variation.

Better yield performances in November 1 and November 15 sowing might be due to the production of higher branching, pods plant^{-1}, seeds pod^{-1} and larger size of the seed. The results suggested that the crop sown on November 1 and 15 gave significantly higher seed yield (2037 and 2017 kg ha^{-1}, respectively) than December 1 and December 15 sowing **(**1437 and 1111 kg ha^{-1}, respectively). The yield reduction in December 1 was 29.45% and 28.75% and in December 15 was 45.45% and 44.91% over November 1 and 15 sowing, respectively. The results are in agreement with the findings of Kumar *et al.* (1988), Dixit (1992) and Sharma and Paul (1999). The highest seed yield in November 1 and 15 sowing indicates its optimum sowing dates for chickpea. The results also suggest that too late sowing (December 15) drastically reduces the seed yield. The higher seed yield in early sowing might be due to the cumulative effect of higher branching, pods plant^{-1}, seeds pod^{-1} and higher seed size, enhanced by the prevailing temperature and soil moisture spread over the growing period. The decrease in yield due to late sowing might be due to high temperature prevailing during flowering, pod setting and grain filling stages. Saini and Faroda (1997) also reported that chickpeas those planted too late in the season undergo "forced maturation" and their yields suffered accordingly.

Table 2. Interaction effects of date of sowing and cultivars on yield and yield contributing characters of chickpea varieties

Treatments	Plant height (cm)	Branches plant^{-1} (no.)	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	1000-seed weight (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	H.I. (%)
Sowing date × variety:								
November 1								
Binasola-4	44.40 d	5.20	70.00 c	1.93	125.33	2021 bc	3489 a	36.73 c
Binasola-3	46.37 bc	5.10	76.33 b	1.86	165.00	2031 bc	3479 a	36.86 bc
Hyprosola	43.47 d	4.83	64.13 d	1.92	103.00	2000 bc	3251 c	38.08 a
November 15								
Binasola-4	46.87 ab	5.37	69.93 c	1.90	127.40	2085 a	3498 a	38.01 a
Binasola-3	48.40 a	5.10	80.76 a	1.87	163.33	2036 b	3484 a	36.88 bc
Hyprosola	45.03 cd	5.00	66.33 d	1.80	102.47	1991 c	3303 b	37.60 ab
December 1								
Binasola-4	38.23 e	3.77	65.41 d	1.68	120.63	1452 d	2786 d	34.26 d
Binasola-3	36.43 f	3.73	65.60 d	1.70	157.50	1435 d	2780 d	34.05 d
Hyprosola	35.43 fg	3.47	58.57 e	1.62	96.83	1425 d	2696 e	34.58 d
December 15								
Binasola-4	34.07 g	2.57	35.53 f	1.43	117.13	1118 ef	2298 f	32.73 f
Binasola-3	34.00 g	2.83	36.97 f	1.30	154.67	1129 e	2276 f	33.17 ef
Hyprosola	31.50 h	2.50	32.40 g	1.28	91.83	1085 f	2110 g	33.95 de
$LSD_{0.05}$	1.66	NS	3.01	NS	NS	37.96	42.66	0.79
CV (%)	1.73	5.90	2.10	3.86	0.79	0.96	0.61	0.93

Means in a column followed by same letter are not significantly different at 5% level of significance by DMRT; LSD = Least Significant Difference; CV = Co-efficient of Variation.

Conclussion

It could be concluded that November 1 to 15 sowing can be recommended as optimum sowing time for higher seed yield in chickpea.

References

Aravandia, M. K. and Patel, Z. G. 1988. Influence of dates of sowing on the growth and yield of gram under different fertility levels. Gujrat Agril. Univ. Res. J. 13(2): 65-66.

BBS (Bangladesh Bureau of Statistics). 2005. Statistical yearbook of Bangladesh, Statistics Division, Ministry of Planning, Government of Bangladesh, Dhaka, p. 62.

BARC (Bangladesh Agricultural Research Council). 2005. Fertilizer Recommendation Guide. Published by BARC, Dhaka, Bangladesh.

Blevins, R. L. 1986. An Overview of approaches to reduced tillage. Proc. Intl. Symp. On minimum tillage held on 26-27 February, 1986 at BARC, Dhaka, Bangladesh. In: Bangladesh J. Agril. Sci., 1993. 20(1): 99-105

Dixit, J. P. 1992. Growth behavior and production of chickpea in relation to sowing time and moisture levels. Crop Res., Hissar, 5 (Suppl.): 87-91.

Jodah, N. S. and Rao, K. V. S. 1986. Chickpea World Importance and Distribution. The Chickpea. Ed. M. C. Saxena and K.B. Singh. Published by CAB. International, Wallingford, Oxon, OX10 8DE, UK, pp. 1-10.

Khan, M. S. H., Solaiman, A. R. M., Hoque, M. S. and Rahman, M. M. 1997. Response of chickpea to *Rhizobium* inoculation and NPK fertilization on nodulation, dry matter production and N uptake. Ann. Bangladesh Agric., 7(1): 21-26.

Kumar, J. H. A., Rheenan, V. and Saxena, N. P. 1988. A note on the prospects of winter planting of chickpea in Kashmir Valley of Jammu and Kashmir state, India. Legume Res., 11(4): 196-198.

Sharma, D. N. N. and Paul, S. R. 1999. Sowing time of chickpea cultivers under hills zone of Assam. Indian J. Agron., 44 (2): 370-372.

Saini, S. S. and Faroda, A. S. 1997. Effect of sowing time, its pattern and seed rate on growth and yield of chickpea. Indian J. Agron., 42(4): 645-649.

Van Rheenen, H. A. 1991. Chickpea breeding progress and prospects. Plant Breeding Abstract., 61(9): 997-1005.

Yadav, D. S. 1992. Pulse crops. Kalyani publications, First editions. New Delhi, India, pp. 27-31.

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INFLUENCE OF GROWING SEASON AND PLANTING DATE ON BACTERIAL WILT OF TOMATO

H. A. Begum[1] and M. K. Hasna[1]

Abstract

Two experiments were carried out at Bangladesh Institute of Nuclear Agriculture (BINA) farm, Mymensingh. In first experiment, four varieties were used to evaluate the efficacy of growing seasons in reducing the incidence and severity of bacterial wilt of tomato transplanted on summer and winter seasons of 2009. Disease incidence and severity were comparatively lower in the winter season than the summer season. The lower disease incidence and severity were recorded in Binatomato-3 and BARI Tomato-5. In second experiment, seedlings of a susceptible variety Pusaruby were transplanted in five consecutive dates at an interval of 15 days beginning from 16th September 2009 to find out the optimum transplanting dates for the management of bacterial wilt of tomato caused by *Ralstonia solanacearum.* Seedlings transplanted on 1st and 16th November had remarkably less percentage of wilted plants than the plants transplanted on 16th September to October.

Key words: Growing season, *Ralstonia solanacearum*, Tomato, Transplanting date

Introduction

Tomato (*Lycopersicon esculentum* L.) is known to suffer from at least ten diseases in Bangladesh (Meah and Khan, 1987). Among them bacterial wilt is a potential threat to successful cultivation of tomato. Bacterial wilt may result 100% yield loss of tomato under severe attack (Bari, 2001). It is also a devastating disease affecting vascular bundle of plants (Singh, 2002). *Ralstonia solanacearum*, the causal organism of bacterial wilt of tomato is soil borne. However, seed association and seed transmission of *R. solanacearum* are not clearly known. High moisture and temperature in soil are favorable condition for tomato wilt. Poorly drained soil is also a conducive factor for the disease.

A susceptible host is an added factor. All these make the tomato wilt a complex. Growing season has an important influence on the disease incidence and yield of tomato. Adjustment of transplanting dates to check specific disease(s) has already been emphasized in different parts of the world (Rahman *et al.*, 1995). Some diseases become destructive when susceptible stage of the host plant and optimum soil and atmospheric condition for aggressiveness of the pathogen coincide. Alternation of transplanting date in such a way that the susceptible stage of the host plant does not coincide with the favorable

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environment for the pathogen not only helps in disease reduction but also increases the yield of tomato. Therefore, the present study was undertaken to determine the effect of growing season and transplanting time on disease incidence and severity of bacterial wilt of tomato.

Materials and Methods

Assessment of seasonal efficacy

Tomato plants were planted on two subsequent growing seasons of 2009, summer and winter at BINA farm, Mymensingh. Seeds of four varieties such as Binatomato-2, Binatomato-3, BARI Tomato-4 and BARI Tomato-5 were sown on 15th March (for summer season) and on 15th October (for winter season). The experiment was conducted in a two factors randomized complete block design with three replications. The factors were (i) seasons (summer and winter) and (ii) varieties (four varieties such as Binatomato-2, Binatomato-3, BARI Tomato-4 and BARI Tomato-5). Thirty days old seedlings were transplanted with a spacing of 50 cm between rows and plants. The unit plot size was 2 m × 1.5 m. Twelve healthy seedlings of each variety in a plot were inoculated with two day-old culture of *R. solanacearum* at 30 days after transplanting (DAT) by soil drenching method (Gangopadhyay, 1984). The fertilizers were applied at recommended doses. Recommended cultural practices were also followed as and when necessary. Wilting of plants was recorded regularly. Disease severity (DS) was recorded following (0-5) scale (Rahman and Haque, 1986). Percent disease incidence (PDI) and severity were recorded at 15 days after inoculation.

Effect of transplanting dates

The experiment was conducted during September 2009 to March 2010. Thirty days old tomato seedlings were transplanted in five consecutive dates at an interval of 15 days beginning from 16 September 2009. Ten tomato seedlings were transplanted in each line and all the plants were inoculated with two day-old culture of *R. solanacearum* at 30 DAT. After inoculation the symptoms of bacterial wilt were recorded regularly up to 6 weeks to observe the effect of transplanting dates on the development of the disease. The experiment was carried out in a randomized complete block design. Pusaruby, a susceptible variety to bacterial wilt of tomato (Ramkishum, 1987) was used in the experiment. The spacing for line to line and plant to plant was 50 cm. Seeds or plants were not given any insecticidal and fungicidal treatments. Intercultural operation, method of inoculation and data recording were the same as described earlier.

Results and Discussion

Assessment of seasonal efficacy

The four varieties showed susceptible reaction to bacterial wilt in both the seasons. Higher mortality (65.83%) and disease severity (3.8) of bacterial wilt were recorded in the summer season than the winter season (DI = 55.83% and DS = 3.5) (Table 1). Though the four varieties showed susceptible reaction to bacterial wilt, the variety BARI Tomato-5 showed significantly least disease incidence (51.67%) and severity (3.3) compared to rest of the varieties. Irrespective of season, significantly higher disease incidence and severity of bacterial wilt were recorded in Binatomato-2 and BARI Tomato-4 than the other two varieties, BARI Tomato-5 and Binatomato-3 (Table 2). All the varieties were graded as moderately susceptible to susceptible to the disease.

Table 1. Effect of four varieties of tomato on the incidence and severity of bacterial wilt of tomato during the summer and winter seasons of 2009

Treatments	Disease incidence (%)	Disease severity (0-5)	Disease reaction
Growing seasons			
Winter	55.83	3.5	S
Summer	65.83	3.8	S
LSD (p > 0.01)	5.56	0.05	
Varieties			
BARI Tomato-5	51.67	3.3	S
Binatomato-3	53.33	3.5	S
BARI Tomato-4	68.33	4.0	S
Binatomato-2	70.00	3.8	S
LSD (p > 0.01)	17.69	0.77	

S = susceptible, LSD = least significant difference

Table 2. Interaction effect between growing seasons and varieties on the development of bacterial wilt of tomato

Treatments		Disease incidence	Disease severity	Disease
Seasons	Varieties	(%)	(0-5)	reaction
Summer	Binatomato-3	56.67	3.7	S
	BARI Tomato-5	56.67	3.3	MS
	BARI Tomato-4	70.00	4.0	S
	Binatomato-2	80.00	4.3	S
Winter	BARI Tomato-5	46.67	3.3	MS
	Binatomato-3	50.00	3.3	MS
	Binatomato-2	60.00	3.3	MS
	BARI Tomato-4	66.67	4.0	S
LSD (p > 0.05)		25.02	1.089	

MS = moderately susceptible, S = susceptible, LSD = least significant difference

In the present study, growing season was found to influence the incidence of bacterial wilt of tomato. The incidence and severity of the disease were comparatively lower in the winter season than the summer season. This may be due to low temperature and low moisture content during the period from November to the middle of April. Meah (1994, 1997) and Babar (1999) supported the present findings who stated that for some pathogens, wet season or summer season was found to be favorable for higher disease incidence and severity. Further support comes from Rahman *et al.* (1995), who observed that the incidence of foliar diseases viz. alternaria leaf spot of mustard, anthracnose of chili and bacterial wilt of brinjal was significantly higher in early sown crops than the later sown crops. The later sown crops matured later than early sown crops, due to the occurrence of lower temperature and humidity, hence less incidence of disease occurred.

Effect of transplanting dates

Different dates of transplanting significantly influenced the incidence of bacterial wilt. The incidence of bacterial wilt was significantly minimum (68%) in the plants transplanted on November 16 (Fig. 1). The incidence of the disease was 100% from the 1st transplanting through the 3rd transplanting date (Fig. 2). The incidence of plants transplanted on November 1 ranked second in position which was significantly different from the last transplanting date, November 16.

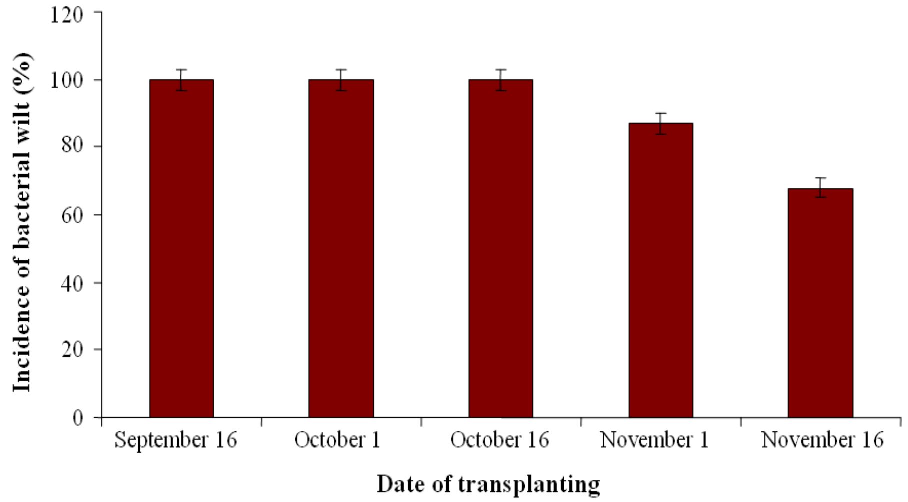

Fig. 1. Effect of transplanting dates on the incidence of wilt of tomato caused by *R. solanacearum*

Fig. 2. Showing hundred percent disease incidence of bacterial wilt in plants transplanted on October 16 (3rd transplanting date)
A = Inoculated plants; B = Uninoculated plants

Tomato plants were seriously damaged (100%) by *R. solanacearum* when they were grown earlier than 16th November. This result is in agreement with the findings of Ahmed and Talukder (1978) who reported that early sowing caused maximum damage of crops from bacterial wilt disease. The early sown crops showed more vegetative growth forming a dense canopy which provided high humidity under the plants that favoured the growth of pathogens. The disease severity depends on the sensitivity of host as well as the climatic factors, specially temperature (Singh, 2002). Bacterial wilt caused by *R. solanacearum* is subjected to be maximum if the environmental factors, pathogen and host could be placed at optimum conditions (Girard *et al*., 1993; Meah, 1994; Bari, 2001). Gradual decrease in the incidence of the disease from November 16th onwards might be due to decrease in soil moisture and consequently changes in biotic factors and temperature (Ahmed and Talukder, 1978). The findings of the present study indicated that late transplanting (after 16 November) of tomato is advisable at Mymensingh until resistant varieties are developed.

References

Ahmed, M. K. and Talukder, M. J. 1978. Effect of time of planting on the incidence of bacterial wilt disease of tomato. Bangladesh J. Biol., 7(1): 105-106.

Babar, H. M. 1999. Studies on collar rot of sunflower. Ph.D Thesis, Submitted to the Department of Plant Pathology, Bangladesh Agricultural University, Mymensingh, p. 189.

Bari, M. A. 2001. Study on bacterial wilt of solanaceous crops in Bangladesh. M.S. Thesis, Plant Pathology Department, Bangladesh Agricultural Research Institute, Gazipur, p. 43.

Gangopadhyay, S. 1984. A Book of Clinical Plant Pathology. Kalyani Publishers. 4863/2B, Bharat Ram Road, 24, Daryaganj, New Delhi-110002, India, p. 367.

Girard, J. C., Nicole, J. F., Cheron, J. J. A, Guabiae, A. M., Huvier, O., Oudard, B. and Suzor, H. 1993. Bacterial wilt due to *Pseudomonas solanacearum* in Reunion: General status of current research. *In:* Hartman, G.L. and Hayward, A.C., (Eds.). Bacterial Wilt. Proceedings of an International Conference held at Kaohsiung, Taiwan, 28-31 October 1992. ACIAR Proceedings No. 381.

Meah, M. B. and Khan, A. A. 1987. Survey of disease of some important fruits and vegetables of Bangladesh. Annual Progress Report (1988-89), Department of Plant Pathology, Bangladesh Agricultural University, Mymensingh, p. 28.

Meah, M. B. 1994. Disease in Kharif crops under crop diversification programme. Report Crop Diversification Programme. Dept. Agric. Ext., Dhaka, p. 12.

Meah, M. B. 1997. Diseases in Rabi crops under crop diversification programme. . Report Crop Diversification Programme. Dept. Agric. Ext., Dhaka, p. 10.

Rahman, M. A. and Haque, M. O. 1986. Screening of tomato varieties/lines against bacterial wilt. Bangladesh J. Plant Pathol., 2(1): 15-18.

Rahman, M. H., Agarwal, V. K., Thaplial, P. N. and Singh, R. A. 1995. Effect of date of sowing and seed treatment on seedling emergence and disease incidence on soybean. Bangladesh J. Plant Pathol., 11 (1 & 2): 19-22.

Ramkishun, 1987. Loss in yield to tomato due to bacterial wilt caused by *Pseudomonas solanacearum*. Indian Phytopathol., 40(2): 152-155.

Singh, R. S. 2002. Introduction to Principles of Plant Pathology. Forth edition. Oxford & IBH publishing Co. PVT. Ltd. New Delhi. 110002, India, p. 402.

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INSECTICIDAL ACTIVITY OF FOUR INDIGENOUS PLANT EXTRACTS AGAINST PULSE BEETLE, *Callosobruchus chinensis* L. UNDER LABORATORY CONDITION

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Abstract

Experiments were carried out in the laboratory of Entomology Division, Bangladesh Institute of Nuclear Agriculture (BINA) to evaluate the efficacy of four indigenous plant extracts of turmeric (*Curcuma longa*), black pepper (*Piper nigram*), eucalyptus (*Eucalyptus camaldulensis*) and garlic (*Allium sativum*) at the rate of 10.0, 7.5, 5.0 and 2.5 per cent for their residual, surface protection and repellent effects against the pulse beetle (*Callosobruchus chinensis* L.). The results showed that extracts of all the plants had repellency, residual effect and grain protection values. It was also observed that turmeric and black pepper were more effective than eucalyptus and garlic. Turmeric extracts showed the highest (53.99%) repellent action and garlic showed the lowest (27.32%). The effectiveness of all the plant extracts was found to increase with the increase of doses and decreased proportionately with the increase of time. The tested plant extracts provided good protection of black gram seeds by reducing insect oviposition, adult emergence, grain damage rate, percent weight loss and increasing inhibition rate.

Keywords: Insecticidal activity, Plant extract, Pulse beetle

Introduction

Pulses are one of the important crops in Bangladesh which is very rich in protein (20-30%) (Sharma, 1984). Pulses have traditionally been called the poor man`s meat. They are the cheapest source of protein and amino acids. Pulses are the main sources of plant protein, especially in the developing nations, particularly in Bangladesh. Pulses play a significant role in the diet of common people of Asian countries including Bangladesh. In Bangladesh per capita consumption from the animal protein is very low (Saehdeva and Sehgal, 1985). It plays a vital role in the nutrition of the people of Bangladesh. Recently, pulse production is gradually decreasing day by day.

Several factors are responsible for this declining trend of which vartietal instability, insect infestation and diseases are important. Pulses are more difficult to store than cereals as these suffer a great attack from insect pest and micro-organisms. Several species of pulse

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beetle are reported to attack pulses in storage of which *C. chinensis* L., *C. maculates* F. and *C. analis* are major (Husain, 1995). C. *chinensis* L. is one of the most destructive pests of almost all kind of pulses in storage and also to some extent in the field (Patnaik, 1984; Rajapakse, 1989). The damage to pulses by pulse beetle is very high and quite often each and every seed is infested and as a result the pulse seeds become unfit for human consumption (Atwal, 1976; Husain, 1995). It causes a great loss in seed weight and protein content of the seeds. The pulse beetle may cause 10-95% loss in seed weight and 45.5-66.3% loss in protein content of the seeds under normal condition and the severity of damage increases with the duration of storage (Gujar and Yadav, 1978). The germination rate of the pulse seed is also reduced to a great extent (Yadav, 1985). The degree of damage varies with different kinds of legumes, duration of exposure time, storage facilities and other factors associated with seeds. Under farmer`s storage condition, as high as 64.33% grains of chickpea were recorded to be damaged by *C. chinensis* in Bangladesh (Husain, 1995).

In Bangladesh, the insect-pest are mainly controlled by synthetic insecticides. Continuous and indiscriminate use of synthetic insecticides has got many limitations and undesirable side effects. Botanical pesticides are generally much safer to human beings and to the environment than conventionally used synthetic pesticides; thus, these are used for millions of years without any ill or adverse effect on ecosystem. (Bhaduri *et al.,* 1989; Haque and Husain, 1993). However, a few scientific research works by these materials have been done in Bangladesh to explore our locally available plant materials for the control of harmful insect pests in storage and field level. These botanical materials can be used as an alternative to chemical pesticides. Therefore, the present study was undertaken to study the insecticidal activity of four indigenous plant extracts against the pulse beetles with the following objective:

To study the insecticidal activities of four different plant extracts as surface protestant of the seed, residual toxicity and repellent effect against the pulse beetle.

Materials and methods

Experiments on the insecticidal activity of four plant extracts viz., eucalyptus, black pepper, turmeric and garlic against pulse beetle, *C. chinensis* L. were carried out in the laboratory of Entomology Division, BINA, Mymensingh during the period from May 2007 to February 2008. Black pepper, turmeric and garlic were collected from the local market and eucalyptus leaves were collected from road side plants at Bangladesh Agricultural University, BAU campus, Mymensingh. *C. chinensis* was used as test insect in the present studies.

Insect Culture Maintenance

A stock culture of the insects was maintained in the laboratory, at 27-30ºC temperature and 70-75% relative humidity. Fifty pairs of adult pulse beetle (about 1-3 days old) were placed in glass jar containing the rearing material (black gram). The jar was then sealed and was allowed for free mating and oviposition for a maximum period of 7 days. The parent stocks were removed and the grain or pulses containing eggs were transferred to preconditioned food material (black gram) in the breeding jar. The jars were coverd with pieces of cloth, fastened with rubber bands to prevent the contamination and escape of insects. Rearing of these insects was being continued for experimental purpose.

Preparation of Plant Dust & Extracts

Fresh leaves, seeds and rhizomes of eucalyptus, black pepper, garlic and turmeric were washed in running tap water in the laboratory. Then they were dried in shade and in the oven to gain constant weight. The dried materials were ground with the help of a grinder and passed though a 25-mesh sieves to obtain fine dust. Ten gram of ground material of each plant were separately mixed with 200 ml of ethanol and the mixture was then stirred for 30 minutes in a magnetic stirrer and left to stand for next 24 hours. The mixture was then filtered through a fine cloth and again through filter paper (Whatman no. 1). The filtrate was then boiled for solvent evaporation in a hot water bath at 55ºC to a constant weight of extract. After evaporation of solvent from filtrate, the condensed extracts were preserved in tightly corked labeled bottles and stored in a refrigerator at 5^{o}C temperature until they were being used for insect bioassay.

Preparation of Stock Solution

10, 7.5. 5.0 and 2.5% of each category of plant extracts were prepared dissolving in the respective solvent prior to insect bioassay.

Insect Bioassay

Insect bioassays were done in the laboratory under ambient conditions. The present study was divided into following bioassays.

Residual Toxicity

Residual toxicity test was done by exposing pulse beetles in each Petri dish (9cm diameter) having 100g black gram seeds treated with each plant extracts (2.5, 5, 7.5 & 10%). Residual toxicity effect was evaluated by observing mortality of insects released in the treated blackgram seed at 3 intervals i.e. 5, 7 and 9 days after treatment. Five pairs of newly emerged pulse beetles were taken in each petridish for each concentration and were covered. Control treatments (untreated) were performed side by side. Data on insect mortalities were converted into percentage by the following formula:

$$\text{Mortality (\%)} = \frac{\text{Total number of mortality of pulse bettles in each Petri-dish}}{\text{Total number of pulse bettles in each Petri-dish}} \times 100$$

Surface protection Effects

a) Oviposition and Fecundity

Five pair of newly emerged beetles were released in the petridishes containing black gram seeds treated with different concentrations of each plant extracts for recording oviposition and fecundity. Male and female insects were always maintained as 1:1 ratio. Control treatments were done side by side. There were five replications for each treatment. The oviposition and fecundity rate was recorded after 7 days of the release of beetles. The eggs laid on blackgram seeds of each treatment in the petridish were counted individually by using hand lens. Data on number of seeds having eggs, number of eggs per seed and total number of eggs were recorded.

b) Adult Emergence

The pulse beetle started to emerge after 26 days of egg laying. The emerged beetles were counted and removed every day from the Petri-dish. The number of adult beetles were counted daily from the date of first emergence to at least 7 days. The adult emergence rate was calculated.

c) Seed Weight Loss

After hatching larvae entered into the seeds and fed on the cotyledons where they pupated and after pupation they came out as adult by making holes on the seed. The seed weight losses caused by the feeding of larvae were determined. The black-gram seeds were separated from dust particle of seeds and dead bodies of pulse beetle by sieving and winnowing. The cleaned infested seeds in each petridish were weighed separately. The seed weight losses were calculated by subtracting the final weight from the initial weight in each Petri-dish. The seed weight losses were converted into percentage by the following formula:

$$\text{Seed weight loss (\%)} = \frac{A-B}{A} \times 100$$

Where, A = Initial weight, B = Final weight

d) Seed Damage

Each and every seed was taken out from the petridish after the completion of counting the adult beetles to determine the number of hole(s) on each seed after feeding inside. Seeds containing hole(s) were considered as damaged seeds. The number of damaged blackgram seeds were counted and recorded for each replication.

In this test the following observations were recorded

1. Number of adults emerged
2. Grain damage rate and weight loss rate at the end of the experiment
3. The inhibition rates IR(%) using the following formula:

$$IR\ (\%) = \frac{Cn-Tn}{Cn} \times 100$$

Where,

Cn = Numbe of insects in control Petri-dish.

Tn = Number of insects in treated Petri-dish.

Repellency

The repellency test was conducted according to the method of Talukder and Howse (1993). For repellency test plant extracts were diluted with respective solvents to prepare (2.5, 5.0, 7.5 and 10%) solutions. Petri-dishes were divided into two parts, treated and fresh grain portion (untreated). With the help of a pipette, 1.0 ml solution of each plant extract was applied to one half of the grains. The treated half was then air- dried. Ten insects (5 male and 5 female) were released at the center of each Petri-dish and a cover was placed on the Petri-dish. There were five replications for each dose of each plant extract. Then the insects present each portion were counted at hourly intervals up to fifth hour. The data were expressed as percentage repulsion by the following formula:

$$PR\ (\%) = \{(Nc-50) \times 2\ \%)\}$$

Where,

PR = Percentage repulsion

Nc = The percentage of insects present in the control half

Positive (+) values expressed repressed repellency and negative (-) values attractency. Data (PR%) was analysed using analysis of variance (ANOVA) after transforming them into arcsine percentage values. The average values were then categorized according to the following classes (Mc Donald *et al.,* 1970).

Class	Repellency rate (%)
0.	>0.01 to 0.1
I.	0.1 to 20.0
II.	20.1 to 40.0
III.	40.1 to 60.0
IV.	60.1 to 80.0
V.	80.1 to 100.0

Statistical Analysis

The experimental data were statistically analyzed by two factors completely randomized design using MSTAT statistical software in a microcomputer. The mean values were adjusted by Duncan's Multiple Range Test (DMRT).

Results and Discussion

Residual Effect

The efficacy of black pepper, eucalyptus, turmeric and garlic extracts as protectants for black gram grains has been evaluated by residual toxicity by feeding the treated black gram grain at different DAT and the results are shown in Table 1. When the adults were released at different concentrations of all the plant extracts, the highest mortality (93.33%) was observed in 10% concentration of turmeric at 5 DAT and the lowest mortality (26.66%) was observed in 2.5% concentration of garlic at 9 DAT. It was observed that the mortality percentage of insects decreased with increase of time. The order of residual toxicity of the four plant extracts on pulse beetle were Turmeric >Black pepper> Eucalyptus>Garlic.

Table 1. Mean mortality percentage of pulse beetle in blackgram treated by some concentrations of different plant extracts at three different DAT.

Plant extract	Dose (%)	Mortality (%)		
		5 DAT	7 DAT	9 DAT
Blackpepper	10.0	90.00ab	76.66 ab	60.00 ab
	7.5	88.33 cd	70.00 cd	53.33 cd
	5.0	73.33 fg	60.00 fg	43.33 fg
	2.5	63.33 ij	50.00 ij	33.33 ij
	Control	30.00 l	23.33 l	20.00 l
Eucalyptus	10.0	86.60 bc	73.30 bc	56.66 bc
	7.5	80.00 de	66.66 de	60.00 de
	5.0	70.00 gh	56.66 gh	40.00 gh
	2.5	60.00 jk	46.66 jk	30.00 jk
	Control	33.33 l	20.00 l	16.66 l
Turmeric	10.0	93.33 a	80.00 a	63.33 a
	7.5	86.66 bc	73.33 bc	56.66 bc
	5.0	76.66 ef	63.33 ef	46.66 ef
	2.5	66.66 hi	53.33 hi	36.66 hi
	Control	30.00 l	23.33 l	20.00 l
Garlic	10.0	83.33 cd	70.00 cd	56.66 bc
	7.5	70.00 gh	56.66 gh	40.00 gh
	5.0	63.33 ij	50.00 ij	33.33 ij
	2.5	56.66 k	43.33 k	26.66 k
	Control	30.00 l	23.33 l	20.00 l
S-x		2.021	1.794	1.597
Probability level		0.05	0.05	0.01

DAT = Days after treatment

Within column, values followed by different letter(s) are significantly different by DMRT.

Surface Protectant effect

The surface protectant effect of eucalyptus, blackpepper, turmeric and garlic was evaluated against the pulse beetle under laboratory conditions. Number of eggs laid, number of adults emerged, grain damage, weight loss varied significantly among the treated and untreated seeds and also at different concentrations of plant extracts (Table 2).

The beetles laid the lowest number of eggs (19.33) on the grain treated with 10% concentration of turmeric followed by 7.5% turmeric (37.33), 10% Blackpepper (45.00), 5% turmeric (60.33), 7.5% black pepper (70.00) and 10% eucalyptus (72.00). Significantly the lowest number of adults was emerged from 10% turmenic treated grain while the highest was emerged from 2.5% garlic treated grain. The lowest grain damage rate (2.82%) was recorded in the grains treated with 10% turmeric and highest (27.01%) with 2.5% garlic. The minimum weight loss (1.46%) was observed in grains treated with 10%

Table 2. Effect of different plant extracts on eggs laid adult and emerged of pulse beetle and seed damage, weight loss and IR of black gram seed

Plant Extract	Dose (%)	Eggs Laid	Adults Emerged (no.)	Seed damage (%)	Weight Loss (%)	IR (%)
Black-pepper	10.0	45.00n	31.33k	7.43jk	3.86kl	77.61b
	7.5	70.00l	49.00ij	11.45hi	5.95ij	64.99c
	5.0	85.33j	59.00i	13.59h	7.06i	57.85de
	2.5	102.66h	71.67h	17.01g	8.84gh	48.80f
	Control	170.00c	140.00bc	33.33ab	17.33ab	0.00j
Eucalyptus	10.0	72.00l	55.00i	12.65h	6.57i	62.83cd
	7.5	92.67i	70.00h	16.24g	8.44h	52.47ef
	5.0	111.66g	85.33g	19.66f	10.22fg	42.34g
	2.5	13066f	100.00g	22.74de	11.82de	32.42h
	Control	162.00d	148.00ab	35.38a	18.40a	0.00j
Turmeric	10.0	19.33p	13.67l	2.82l	1.46m	89.94a
	7.5	37.00o	25.67k	5.55k	2.88l	81.12b
	5.0	60.33m	44.00j	9.66ij	5.11jk	67.64c
	2.5	79.00k	55.67i	12.73h	6.66i	54.16ef
	Control	182.00a	136.00c	32.56b	16.93b	0.00j
Garlic	10.0	92.00i	72.00h	16.92g	8.84h	51.99ef
	7.5	115.00g	90.67fg	21.37ef	11.11ef	39.55g
	5.0	128.33f	103.00e	24.27d	12.62cd	31.33h
	2.5	142.33e	112.67d	27.01c	13.46c	24.88i
	Control	175.00b	150.00a	35.90a	18.67a	0.00j
Sx		1.356	3.299	35.90a	0.4683	2.168
Probability level		0.01	0.01	0.01	0.01	0.01

Within column, values followed by different letter(s) are significantly different by DMRT.
IR = Inhibition Rate

turmeric. The maximum inhibition rate (89.94%) was observed in grains treated with 10% turmeric and minimum with 2.5% garlic extracts. When the total surface protectant effects of all doses were computed, it was observed that turmeric, black pepper, eucalyptus and garlic extracts deterred oviposition of pulse beetle and reduced the survival percentage of eggs.

These results are in agreement with there of Thomas and Callaghan (1999) and Rahman (1998) who found that garlic and turmeric are more toxic to the insects. The lowest number of eggs (75.60), reduced rate of adults emerged (55.00), grain damage (12.66%), weight loss (6.60%) and the highest inhibition rates (89.94%) were recorded in grain treated with turmeric. The number of eggs decreased with increasing concentrations of botanicals (black pepper seeds, mint leaves and neem karnels) used, reported by Juneja and Patel (2002). Sangwang *et al.* (2005) carried out an experiment where, pigeon pea seeds were treatd with 11 seed protestants against pulse beetle. All the seed protectants except for sawdust, recorded significantly higher adult mortality than the control after the first day of treatment.

Results showed that the number of egg laying, number of adult emergence, seed damage percentage and percentage of seed weight loss decreased with increased dose of extract and IR% also increased with increases of dose. It was suggested that the good potentiality of using turmeric, black pepper, eucalyptus and garlic as protectant agents in storage management of pulse bettle in Bangladesh.

Effect of plant extracts as repellent

The repellency rate of different plant extracts at different hours after treatment (HAT) is presented in Table 3. The mean repellency rate of different plants extracts was found statistically significant. Among the four plants extracts tested, turmeric showed highest (53.99%) mean repellency effect followed by blackpepper (47.32%), eucalyptus (40.66%) and garlic (27.32%). All the treatments excluding garlic graded as class III. Garlic was fallen into class II.

The repellency rate of different plant extracts at level of concentrations on pulse beetle is presented in Table 4. The repellency rate increased with the increase of doses. The mean repellency rate among different doses was found to be significant statistically.

The interaction effects of plant, dose and time are shown in Table 5. The highest mean repellency rate was found with 10% turmeric extract (63.99%) and the lowest rate was found with 2.5% garlic extract (17.33%).

Jilani and Sexena (1987) observed that indigenous plants such as Neem, Turmaric and sweet flag possessed insect repellent properties, Sharaby (1988) evaluated the toxicity, repellency and LC50 of sun dried guava and eucalyptus leaves against *S granaries* and *S oryzae*. He reported that eucalyptus leaves were more repellent than guva leaves.The repellency action of all the four plant extracts on the pulse beetle was statistically significant. On the basis of mean repellency rate, it was found that eucalyptus, turmeric, blackpepper and garlic extracts were in different repellency class (Table 5). It was also found that the repellency rate increased with the increase of doses.

Table 3. Effect of different plant extracts on repellency at different HAT

Plant extracts	Repellency rate (%)					Mean Repellency rate (%)	Repellency Class
	1 HAT	2 HAT	3 HAT	4 HAT	5 HAT		
Blackpepper	46.66b	46.66b	44.99b	48.33b	49.99b	47.32b	III
Eucalyptus	38.32c	41.66c	38.32c	41.66c	43.33c	40.66c	III
Turmaric	51.66a	54.99a	51.66a	54.99a	56.66a	53.99a	III
Garlic	24.99d	28.32d	24.99d	28.33d	29.99d	27.32d	II
Sχ	0.9270	0.9843	1.091	0.8720	0.8810	0.7604	
Probability Level	0.01	0.01	0.01	0.01	0.01	0.01	

HAT = Hours after treatment
Within column, values followed by different letter(s) are significantly different by DMRT.

Table 4. Effect of different concentrations on repellency at different HAT

Dose (%)	Repellency rate (%)					Mean Repellency rate (%)	Repellency Class
	1 HAT	2 HAT	3 HAT	4 HAT	5 HAT		
10.0	49.99a	53.33a	48.33a	54.99a	54.99a	52.32a	III
7.5	44.99b	44.99b	43.32b	46.66b	48.33b	45.66b	III
5.0	36.66c	39.33c	36.66c	39.99c	41.66c	38.99c	III
2.5	29.99d	33.33d	31.66d	31.66d	34.99d	32.32d	II
Sx	0.9270	0.9843	1.091	0.8720	0.8810	0.7604	
Probability Level	0.01	0.01	0.05	0.01	0.01	0.01	

HAT = Hours after treatment
Within column, values followed by different letter(s) are significantly different by DMRT.

Table 5. Repellent effects of different plant extracts at different concentrations at different HAT

Plant extracts	Dose (%)	Repellency rate (%)					Mean Repellency (%)	Repellency Class
		1HAT	2HAT	3HAT	4HAT	5HAT		
Blackpepper	10.0	60.00a	53.33b	53.33b	60.00b	60.00b	57.33b	III
	7.5	46.66b	53.33b	46.66bc	53.33c	53.33c	50.66c	III
	5.0	46.66b	40.00d	46.66bc	40.00d	46.66d	43.99d	III
	2.5	33.33d	40.00d	33.33d	40.00d	40.00e	37.33e	II
Eucalyptus	10.0	46.66b	53.33b	46.66b	53.33c	53.33c	50.66c	III
	7.5	46.66b	40.00d	46.66b	40.00d	46.66d	43.99d	III
	5.0	33.33d	40.00d	33.33d	40.00d	40.00e	37.33e	II
	2.5	26.66e	33.33e	26.66de	33.33e	33.33f	30.66f	II
Turmeric	10.0	60.00a	66.66a	60.00a	66.66a	66.66a	63.99a	IV
	7.5	60.00a	53.33b	53.33b	60.00b	60.00b	57.33b	III
	5.0	46.66b	53.33b	46.66bc	53.33c	53.33c	50.66c	III
	2.5	40.00c	46.66c	46.66bc	40.00d	46.66d	43.99d	III
Garlic	10.0	33.33d	40.00d	33.33d	40.00d	40.00e	37.33e	II
	7.5	26.66e	33.33e	26.66de	33.33e	33.33f	30.66f	II
	5.0	20.00f	26.66f	20.00e	26.66f	26.66g	23.99g	II
	2.5	20.00f	13.33g	20.00e	13.33g	20.00h	17.33h	I
Sx		1.854	1.969	2.181	1.744	1.762	1.521	
Significant level		0.01	0.01	0.05	0.01	NS	0.01	

HAT = Hours after treatment
Within column, values followed by different letter(s) are significantly different by DMRT.
NS = Not significant

References

Atwal, A. S. 1976. Agricultural pests of India and South-East Asia. Kalyani Publisher, Delhi, p. 502.

Bhaduri, N., Ram A. S. and Patil, B.D. 1989. Evaluation of some plant extracts as protectants against the pulse beetle, *Callosobruchus maculates* (Feb.) infesting cowpea seeds. J. Ent. Res., 9(2): 183-187.

Gujar, G. T. and Yadav, T. D. 1978. Feeding of *Callosobruchus maculates* (Feb.) and *Callosobruchus ehinensis* L. in green gram. Indian J. Ent., 40(2): 108-112.

Haque M. T. and Husain, M. 1993. Ovipositional preference and growth of pulse beetle on some species of pulse beetle. Bangladesh J. Nuclear Agric., 9: 47-53.

Husain, M. 1995. Bangladesher Gudamjat Sashyer Onisthakar Kitpatanga: Jibanbrittantya O Pratikar (Stored grain pests of Bangladesh: Life history and prevention). Bangla Academy, Dhaka, Bangladesh. pp. 48-49.

Jilani, G. and Saxena, R. C. 1987. Derivatives of neem, turmeric and sweet-flag as protectant against stored grain insect pests. International Rice Res. Inst. Los Banos, Manila (Philippines), p. 1.

Juneja, R. P. and Patel, J. R. 2002. Persistence of botanical materials as protectant of green gram, *Vigna radiate* (L.) against pulse beetle (*Callosobruchus analis*). Seed Res., 30(2): 294-297.

McDonald, L. L., Guy, R. H. and Speirs, R. D. 1970. Preliminary evaluation of new candidate materials as toxicants, repellents and attractants against stored product insects. Marketing Res. Serv., U. S. Dept. Agric. Washington, D. C, p. 8.

Patnaik, H. P. 1984. Notes on field infestation of pigeon-pea by *Callosobruchus* sp. In Orissa, Bull. Grain Tech., 22(3): 259-261.

Rahman, L. M. 1998. Laboratory evaluation of Urmoi, Neem and Turmeric for controlling the rice weevil, *Sitophilus oryzae* (L.) and the Grain weevil, S. granaries L. M.S. Thesis, Dept. of Entomology, Bangladesh Agruicultural University, Mymensingh, p. 115.

Rajapakse, R. H. S. 1989. Effect of five botanical as protectants of green gram against the pulse beetle, *Callosobruchus chinensis*. Proc. 2nd Int. Sump. On Bruchids and Legumes (ISBL-2), September, 6(9): 85-99.

Saehdeva, J. S. and Sehgal, S.S. 1985. Ovipositional response and development of *Callosobruchus maculates* Fab. On some new varieties of green, Bull. Grain Tech., 23(10): 3.6.

Sangwang, J., Chhillar, B. S. and Kashyap, T. K. 2005. Effectiveness of various seed protectants on adult mortality of pulse beetle, *Callosobruchus maculates* (F.) infesting pigeon-pea seeds. Annals Biol., 21(1): 65-67.

Sharaby, A. 1988. Evaluation of some Myrtaceae plant leaves as protectants against the infestation by *Sitophilus oryzae* L. and *Sitphilus granaries* L. Insect Sci. Appl, 9: 465-468.

Sharma, S. S. 1984. Review of literature of the losses caused by *Callosobruchus* species (Bruchidae: Coleoptera) during storage of pulses. Bull. Grain Tech., 22(1): 62-68.

Talukder, F. A. and Howse, P. F. 1993. Deterrent and insecticidal effects of extracts of pithraj, *Aphanamixis polystachya* (Meliaceae), against *Tribolium castaneum* in storage, J. Chem. Ecol., 19: 2463-2471.

Thomas, C. J. and Callaghan, A. 1999. The use of garlic and lemon peel extracts as *Culex pipiens* larvacides: persistwence and interaction with an organophosphate resistance mechanism. The University of Reading, UK, 39(4): 2489-2496.

Yadav, T. D. 1985. Anti-ovipositional and ovicidal toxicity of neem (*Azadirachta indica*) oil against three species of *Callosobruchus.* Neem Newsl., 2(1): 5-6.

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EFFECT OF PHOSPHORUS AND BIOFERTILIZER ON YIELD AND YIELD CONTRIBUTING CHARACTERS OF CHICKPEA

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Abstract

An experiment was carried out at the Bangladesh Institute of Nuclear Agriculture (BINA) sub-station farm, Ishurdi during November 2007 to April 2008 to evaluate the effect of phosphorus with biofertilizer on the growth and yield of chickpea. The results of phosphorus and biofertilizer trial demonstrated that biofertilizer had markedly positive influence on the production of nodules, dry weight of nodules, pods plant^{-1}, seeds pod^{-1}, 1000-seed weight, grain yield, stover yield and harvest index. Binasola-3, Hyprosola and Binasola-4 in combination with biofertilizer produced the highest nodule number (27.37, 25.73 and 25.6, respectively) in chickpea. Inoculation of biofertilizer produced higher seed yield (2608, 2518 and 2517 kg ha^{-1} by Hyprosola, Binasola-4 and Binasola-3, respectively).

Key words: Phosphorus, Biofertilizer, Chickpea seed yield

Introduction

The influence of phosphorus (P) on chickpea yield is well documented in Bangladesh and elsewhere. The average responses of chickpea to P over 2181 trials were 7.8 kg grain kg^{-1} P_2O_5 (Tandon, 1987). Application of 75 kg P_2O_5 ha^{-1} to rainfed chickpeas at Deradun, India increased grain yield by 1.1 t ha^{-1} averaged over three years (Tandon, 1987). Optimum P application levels for chickpea ranged from 20-75 kg P_2O_5 ha^{-1} depending on environment (AICRPDA, 1983). Pot trials conducted at ICRISAT (1989), Patancheru, India, clearly showed that the highest levels of P application were required for the vegetative stage of chickpea growth. But for later stages of growth (pod-filling stage), 20 kg P ha^{-1} was required for maximum root development, shoot growth and pod yield. Subsequently, from a HBT (High Barind Tracts, Rajshahi, Bangladesh) experiment on a farmer's field it was further showed that 30 kg P ha^{-1} apparently had superior performance over 0 kg P ha^{-1} in respect of root growth and grain yield. Thus, after getting a postive response to P fertilizer and soil moisture for different genotypes of chickpea in both pot and field trials, and over locations; it became pertinent to more precisely define optimum P fertilizer dose and irrigation for the HBT of Bangladesh so as to formulate appropriate recommendations (Khan *et al.*, 1997).

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In pulse crop, biofertilizer (*Rhizobium* inoculums) can alone produce 40-88 per cent more seed yield (Bhuiyan *et al*., 2001). Application of biofertilizer in pulses, produce higher number of nodules plant^{-1}, pods plant^{-1}, seeds pod^{-1} and seed yield (Alam *et al*., 1999). Chickpea crops are capable of fixing and utilizing atmospheric nitrogen for its growth through symbiotic relationship with *Rhizobium* bacteria. Application of *Rhizobium* culture is an important input in the package of practices for increased pulse production. The response of inoculation depends upon soil type and presence of effective strains of *Rhizobium* on soil. Rahman *et al*. (1994) reported that seed inoculation with suitable strain of *Rhizobium* would improve nodulation and yield of chickpea. Due to poor adoption of high yielding varieties and lack of suitable Rhizobia, the crop yield is often reduced. Therefore, an attempt was made to evaluate the effect of phosphorus and biofertilizer on growth and yield in chickpea.

Materials and Methods

The experiment was conducted at the BINA sub-station farm Ishurdi during November 2007 to April 2008 to evaluate the effect of phosphorus and biofertilizer on growth and yield in chickpea. Two set of treatments were imposed as; (A) Varieties: 3 (Binasola-4, Binasola-3 and Hyprosola) and (B) Fertilizer doses: 5 (Control i.e. recommended fertilizer, biofertilizer and 30, 60 and 90 kg P_2O_5 ha^{-1}). The experiment was laid out in a split plot design with 3 replications. The entire experimental field was divided into three blocks and each block was divided into three main plots and each main plot was divided into five sub-plots. The total plots of the experiment were 45 (3 × 5 × 3). The varieties were placed in the main plot and the fertilizer doses were placed in the sub-plots. After making lay out of the experiment, the lands were fertilized. The phosphorus fertilizer doses were 30, 60 and 90 kg P_2O_5 ha^{-1} as triple super phosphate. The recommended chemical fertilizers were applied @ 20.0, 28.0, 10.0, and 1.0 kg as N, K, S and Zn per hectare, respectively as recommended by the Fertilizer Recommendation Guide (BARC, 2005) in the form of urea, muriate of potash, gypsum and zinc sulphate, respectively. All the fertilizers were applied as basal at the time of final land preparation. Biofertilizer was mixed @ 40 g kg^{-1} seed with molasses and then the seeds were kept in the mixture and stirred by hand for few minutes. A black coating was formed around the seed surface and the seeds were dried under a shed before sowing. Seeds were sown on November 15, 2007 @ 40 kg ha^{-1}. Before sowing, seeds were mixed with fungicide (vitavax 200 @ 2 g kg^{-1} seed). Seeds were sown by hand as uniformly as possible in furrows. Line to line distance was 60 cm. Then the seeds were covered with soil to have a good seed-soil contact. Fresh nodules plant^{-1} (no.) was collected at 45 days after sowing. Dry weight of nodules (mg) and the other plant characters were recorded from ten randomly selected plants. Data were compiled and analyzed through MSTAT computer package and the mean values were judged by DMRT.

Results and Discussion

All the varieties under the study differed significantly for dry weight of nodules, thousand seed weight, seed yield, stover yield and harvest index and fertilizers also showed significant results for all the crop characters (Table 1). Combined effect of varieties and fertilizer showed significant effect for dry weight of nodules, pods plant^{-1}, thousand seed weight, seed yield, stover yield and harvest index (Table 2). Nodules plant^{-1} did not differ significantly for varieties. The biofertilizer inoculation produced significantly higher number of nodules plant^{-1} (26.23) than those of the fertilizer treatments under the study. Application of 30 and 60 kg P_2O_5 ha^{-1} also increased the number of nodules (17.17 and 17.23) followed by 90 kg P_2O_5 (15.41). The lowest number of nodules (12.61) was observed in control. The combined effect (Table 2) showed the highest number of nodules plant^{-1} in biofertilizer treated plot by Binasola-4, Binasola-3 and Hyprosola (25.6, 27.37 and 25.73, respectively). All the varieties showed higher number of nodules plant^{-1} in 30 and 60 kg P_2O_5 ha^{-1} treatment. Highest dry weight of nodules was obtained from Binasola-3 and Hyprosola (65.97 and 65.37 mg, respectively) which were statistically identical. Among fertilizer treatments, biofertilizer produced the highest nodule dry weight (118.22 mg). Higher dry weight of nodules might be due to the production of higher number of nodules plant^{-1}. Combined effect showed the highest dry weight (122.3 mg) in biofertilizer inoculation by Binasola-3. Second highest (117.47 and 114.90 mg) was obtained in .

Table 1. Effect of cultivars and fertilizer levels on yield and yield contributing characters of chickpea

Treatments	Nodules plant^{-1} (no.)	Dry weight of nodule (mg)	Plant height (cm)	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	1000-seed weight (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)
Varieties:									
Binasola-4	17.35	61.74b	37.89	59.87	1.65	119.28b	2116b	3867b	35.26a
Binasola-3	17.91	65.97a	38.14	62.03	1.62	159.22a	2111b	3796c	35.62a
Hyprosola	17.93	65.37a	38.20	62.56	1.63	100.16c	2163a	4138a	34.21b
$LSD_{0.05}$	NS	3.13	NS	NS	NS	1.54	7.78	3.32	0.37
Fertilizers:									
Control	12.61b	57.30b	37.17c	51.10d	1.54b	122.31d	1696e	3346d	33.87c
Biofertilizer	26.23a	118.22a	38.68ab	77.23a	1.78a	133.49a	2548a	4320a	37.06a
30 kg P_2O_5	17.17b	52.57c	39.06a	56.02c	1.62b	124.22c	1774d	3421c	34.12c
60 kg P_2O_5	17.23b	35.08d	37.96a-c	61.10b	1.61b	125.23bc	2311c	4266b	35.08b
90 kg P_2O_5	15.41b	43.62e	37.52bc	61.98b	1.61b	125.86b	2323b	4311a	35.01b
$LSD_{0.05}$	6.29	1.74	1.22	2.21	0.09	1.21	11.50	2.98	0.31
CV (%)	5.50	2.05	2.44	2.73	4.36	0.73	0.41	0.57	0.65

Means in a column followed by same letter are not significantly different at 5% level of significance by DMRT; LSD = Least significant difference; CV = Co-efficient of variation.

biofertilizer inoculation by Binasola-4 and Hyprosola, respectively. Plant height of different varieties ranged from 37.89 to 38.2 cm and it was statistically non-significant (Table 1) but fertilizer treatment affected the plant height. Highest plant height (39.06 cm) was obtained in 30 kg P_2O_5 ha^{-1} and the lowest (37.17 cm) in control plot. Combined effect showed the tallest plant height in biofertilizer inoculation by Binasola-3 (39.10 cm) and 30 kg P_2O_5 ha^{-1} by Hyprosola (39.07 cm) and they were statistically similar. Among the different fertilizer treatments, biofertilizer treated plots produced the highest number of pods (77.23) (Table 1).

Application of 30, 60 and 90 kg P_2O_5 ha^{-1} showed an increasing trend of pod number $plant^{-1}$ (56.02, 61.10 and 61.98, respectively) over control. The combined effect showed highest number of pods (81.1, 75.67 and 74.93) in biofertilizer application by Hyprosola, Binasola-3 and Binasola-4, respectively. Lowest number of pods (49.27, 53.50 and 50.53) was produced in control by all the varieties. Among the varieties, Binasola-4 produced the highest number of seeds pod^{-1} (1.65) and Hyprosola produced the second highest (1.63). Biofertilizer inoculation produced highest seeds pod^{-1} (1.78), control and all doses of phosphurate (30, 60 and 90 kg P_2O_5 ha^{-1}) treatments produced statistically similar number of seeds pod^{-1} (1.54, 1.62 and 1.61, respectively). Combined effect showed the highest seeds pod^{-1} in biofertilizer treated plots by all the varieties. Mean values of main effect showed (Table 1) the highest seed size by Binasola-3 (159.22 g), second highest by Binasola-4 (119.28 g) and the lowest by Hyprosola (100.16 g). The combined effect showed highest seed size 169.3 g, 123.57 g and 107.60 g in biofertilizer by Binasola-3, Binasola-4 and Hyprosola, respectively. All the varieties produced the lowest seed size in control plot, except Binasola-3. Among the different fertilizer treatments, biofertilizer produced the highest seed yield by Hyprosola (2608 kg ha^{-1}), second highest (2518 kg ha^{-1}) by Binasola-4 and 2517 kg ha^{-1} by Binasola-3. Application of 60 and 90 kg P_2O_5 ha^{-1} increased seed yield by all the varieties (Table 2). All the varieties showed lowest seed yield in control treatment. Higher number of nodules, pods $plant^{-1}$ and seeds pod^{-1} contributed the seed yield of the varieties. Stover yield was obtained highest (4611 kg) in 60 kg ha^{-1} and 4609 kg in 90 kg ha^{-1} of P_2O_5 application by Hyprosola which was statistically identical. Biofertilizer inoculated varieties also showed higher stover yield of 4220, 4230 and 4513 kg ha^{-1} by Binasola-4, Binasola-3 and Hyprosola, respectively (Table 2).

Binasola-4 and Binasola-3 produced higher harvest index of 35% and inoculation of biofertilizer showed the highest harvest index of 37%. The combined effect showed the highest harvest index in Binasola-4 with biofertilizer (37.30%) and Binasola-3 (37.26%) but the values were statistically similar. Lowest harvest index was produced by Hyprosola in control.

Results showed that plants receiving inoculums (biofertilizer) produced higher nodulation, dry weight of nodule, pods plant^{-1}, seeds pod^{-1}, 1000-seed weight, grain yield, stover yield and harvest index of chickpea. On the other hand, application of 30 to 90 kg of P_2O_5 gave higher seed yield than control. Similar results were reported by Bhuiyan *et al*., 2001 and Kaul *et al*., 1990. They reported that inoculation of biofertilizer with the application of phosphorus significantly increased the yield of chickpea. This result is in agreement with the findings of Alam *et al.* (1999) who conducted experiment with biofertilizer inoculation in chickpea. Ahmed *et al.* (1991) reported that chickpea yield increased (2.04 t ha^{-1}) with the application of P fertilizer up to 60 kg ha^{-1}. In the present study, chickpea yield increased slightly by application of 90 kg of P_2O_5 ha^{-1}. So, it can be concluded that 60 kg P_2O_5 is economically profitable for chickpea.

Table 2. Interaction effect of cultivars and level of fertilizer on the yield and yield contributing characters of chickpea

Treatments / Interaction	Nodules plant^{-1} (no.)	Dry weight of nodule (mg)	Plant height (cm)	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	1000-seed weight (g)	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)
Binasola-4									
Control	11.47	55.83 cd	37.00	49.27 g	1.50	116.07 g	1719 i	3410 f	33.74 ef
Biofertilizer	25.60	117.47 b	38.73	74.93 b	1.77	123.57 d	2518 b	4220 c	37.30 a
30 kg P_2O_5	16.50	46.93 g	38.72	54.70 ef	1.68	117.33 fg	1836 g	3412 f	34.98 d
60 kg P_2O_5	17.17	47.17 g	37.90	60.03 cd	1.63	119.37 ef	2253 f	4083 d	35.38 cd
90 kg P_2O_5	16.00	41.30 g	37.70	60.40 cd	1.65	120.07 e	2256 f	4206 c	34.90 d
Binasola-3									
Control	13.10	57.30 c	36.66	53.50 f	1.51	155.17 c	1694 j	3150 g	35.12 d
Biofertilizer	27.37	122.30 a	39.10	75.67 b	1.76	169.30 a	2517 b	4230 c	37.26 a
30 kg P_2O_5	16.93	53.50 de	39.37	55.73 ef	1.58	156.47 bc	1742 h	3376 f	33.99 e
60 kg P_2O_5	17.33	51.70 e	37.80	62.10 c	1.64	157.37 b	2300 e	4106 d	35.86 c
90 kg P_2O_5	14.83	45.03 f	37.77	63.17 c	1.59	157.80 b	2305 e	4116 d	35.85 c
Hyprosola									
Control	13.27	58.77 c	37.83	50.53 g	1.61	95.70 j	1674 k	3480 c	32.76 g
Biofertilizer	25.73	114.90 b	38.20	81.10 a	1.80	107.60 h	2608 a	4513 b	36.60 b
30 kg P_2O_5	18.07	57.27 c	39.07	57.63 de	1.59	98.87 i	1745 h	3476 e	33.39 f
60 kg P_2O_5	17.20	51.37 e	38.17	61.17 c	1.56	98.93 i	2381 d	4611 a	34.01 e
90 kg P_2O_5	15.40	44.53 f	37.73	62.37 c	1.61	99.70 i	2409 c	4609 a	34.27 e
$LSD_{0.05}$	NS	3.10	NS	2.83	NS	2.07	19.92	51.54	0.52
CV (%)	5.50	2.05	2.44	2.73	4.36	0.73	0.41	0.57	0.65

Means in a column followed by same letter are not significantly different at 5% level of significance by DMRT; LSD = Least significant difference; CV = Co-efficient of variation.

Conclusion

It could be concluded that biofertilizer and 60 to 90 kg ha^{-1} of P_2O_5 may be recommended for achieving higher seed yield in chickpea.

References

Ahmed, M., Haque, M. M., Hakim, M. A., Begum, M. and Hossain, M. A. 1991. Status of pulse seed crops and their management techniques as practiced by the farmers of four locations of Bangladesh. Bangladesh J. Seed Sci. & Tech., 3(1&2): 73-76.

Alam, M. J., Solaiman, A. R. M. and Karim, A. J. M. S. 1999. Nutrient uptake, yield, yield attributes and protein content of chickpea as influenced by some Rhizobium strains. Ann. Bangladesh Agric., 9(2): 131-138.

AICRPDA (All India Coordinated Research Projects for Dry Areas). 1983. Improved agronomic practices for dry land crops in India, p. 136.

BARC (Bangladesh Agricultural Research Council). 2005. Fertilizer Recommendation Guide. Published by BARC, Dhaka, Bangladesh.

Bhuiyan, M. A. H., Khanam, D., Khatun, A., Hossain, A. K. M. and Islam, M. S. 2001. Nodulation, dry matter weight and grain yield of chickpea as influenced by Rhizobium inoculation. Bangladesh J. Agril. Res., 26(3): 463-466

ICRISAT (International Crop Research Institute for Semi Arid Tropics). 1989. Chickpea Annual Report, 1987, ICRISAT Patancheru, India, pp. 131-180.

Kaul, J. R. 1990. Storage studies on chickpea seed. Inter. Agril. Engineering Conf., Proc. of Conf. held in Bangkok, Thailand on 7-10 December, 11: 541-547.

Khan, M. S. H., Solaiman, A. R. M., Hoque, M. S. and Rahman, M. M. 1997. Response of chickpea to Rhizobium inoculation and NPK fertilization on nodulation, dry matter production and N uptake. Ann. Bangladesh Agric., 7(1): 21-26.

Rahman, M. H. H., Islam, M. Z., Bhuiyan, M. A. H., Khanam, D., Hossain, A. K. M. and Rahman, A. F. M. 1994. Effect of rhizobial inoculation with and without chemical fertilizers on chickpea in Haplaquepts. Bangladesh J. Agril. Sci., 21(2): 273-277.

Tandon, H. L. S. 1987. Phosphorus research and Agricultural production in India, New Delhi, India: Fertilizer Development and Consultation Organization, pp. 7 & 79.

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IMPACT OF IRRIGATION SCHEDULES ON SEED YIELD, WATER USE AND WATER PRODUCTIVITY OF SOME MUSTARD MUTANTS

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Abstract

Field experiment was conducted at three locations to study the impact of different irrigation schedules on the crop growth, yield, evapo-transpiration and water productivity of some mustard mutants/variety. The effect of three irrigation regimes viz. irrigation at vegetative stage, irrigation at flowering stage, irrigation at vegetative plus flowering stage, along with a no irrigated plot (control) were tested. The results revealed that two irrigations applied at vegetative and flowering stages produced the highest seed yield and single irrigation at vegetative or flowering stage produced comparable seed yield (not statistically different from that of 2 irrigations in most cases). The irrigation water productivity was higher with one irrigation at vegetative stage for all locations. Considering the irrigation water use, yield and irrigation water productivity, it can be concluded that mustard should be irrigated twice at vegetative and flowering stages. Considering water economy, specially where groundwater withdrawal causes ecological imbalance, mustard should be irrigated at vegetative stage for optimum yield.

Keywords: Mustard, Irrigation, Evapo-transpiration, Water productivity

Introduction

Mustard is one of the major oilseed crops that is cultivated during the rabi season in Bangladesh. Though the mustard is cultivated in large areas, yet Bangladesh is facing an acute shortage of edible oil. The reason is low yield which is about 0.98 t ha^{-1} (BBS, 2011). To cover the shortage, a huge amount of foreign currency is spent to import oil. In order to increase the production of mustard, emphasis should be given to cultivate high yielding varieties applying different modern management practices with special consideration of irrigation. There is a wide scope for increasing production of mustard, if proper irrigations and other inputs are made (Mandal *et al*., 2006).

Bangladesh receives high average annual rainfall (1500–2200 mm), but 80% of it occurs within the rainy season (June–September) leaving the winter season (November-February) dry. Due to shortage of soil moisture, many areas remain fallow during the winter period. In some areas, mustard is cultivated without irrigation. Several studies in the past have indicated the irrigation need of mustard. Sarkar *et al.* (1991) observed the

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highest yield (1.47 t ha^{-1}) of mustard with one irrigation at the pre-flowering stage. Parihar (1991) observed higher yield with IW/CPE ratio of 0.6 compared to IW/CPE ratio of 0.4 and 0.87. Ehesanuallah *et al.* (1991) found that seed yield increased by two irrigations scheduled at IW/CPE ratio of 0.8 or 2 irrigations given at 30 and 60 days after sowing. Kar *et al.* (2007) obtained highest yield (938 kg ha^{-1}) and water use efficiency (2.45 kg ha^{-1} mm) of mustard with 3 irrigations in sandy loam soil. Mandal *et al.* (2006) observed higher yield of Indian mustard with 60 mm pre-sowing irrigation and 60 mm post-sowing irrigation at vegetative and at flowering stage. The response of mustard to irrigation may vary with cultivars, locations, and time and duration of water deficit or irrigation.

The objective of this experiment was to study the impact of different irrigation schedules on seed yield, water use and water productivity of mustard mutants developed at the Bangladesh Institute of Nuclear Agriculture (BINA) with a view to determine the optimum irrigation schedule of the cultivars.

Materials and Methods

Field experiments were carried out during 2007-08 at three BINA sub-stations i.e. Ishurdi (24°08′ N, 89°03′ E), Magura (2.3°30′ N, 89°35′ E) and Rangpur (25°45′ N, 89°15′ E). The soils are calcareous silt-loam, loam, and sandy loam at Ishurdi, Magura, and Rangpur, respectively. The climate of the regions falls within humid sub-tropic with summer dominant rainfall. The mustard growing period (November–February) is characterized by dry winter. The weather parameters during the crop period are depicted in Fig. 1.

The experimental design was randomized complete block (RCB) with split-plot arrangements of the treatments. Irrigation treatments were allocated in the main plots (6 m × 5 m) and the mustard mutants were placed in the sub-plots (5 m × 2 m) with three replications. The experiments were conducted with same design and treatments in all locations. The irrigation treatments were:

T_0 = Control (no irrigation)
T_1 = Irrigation at vegetative stage (25–30 days after sowing)
T_2 = Irrigation at flowering stage (45–50 DAS)
T_3 = Irrigation at vegetative stage (25–30 DAS) and flowering stage (45–50 DAS)

The mustard mutants/variety were:

V_1 = MM014-02
V_2 = MM2-16-98
V_3 = Binasharisha-3 (Check variety)

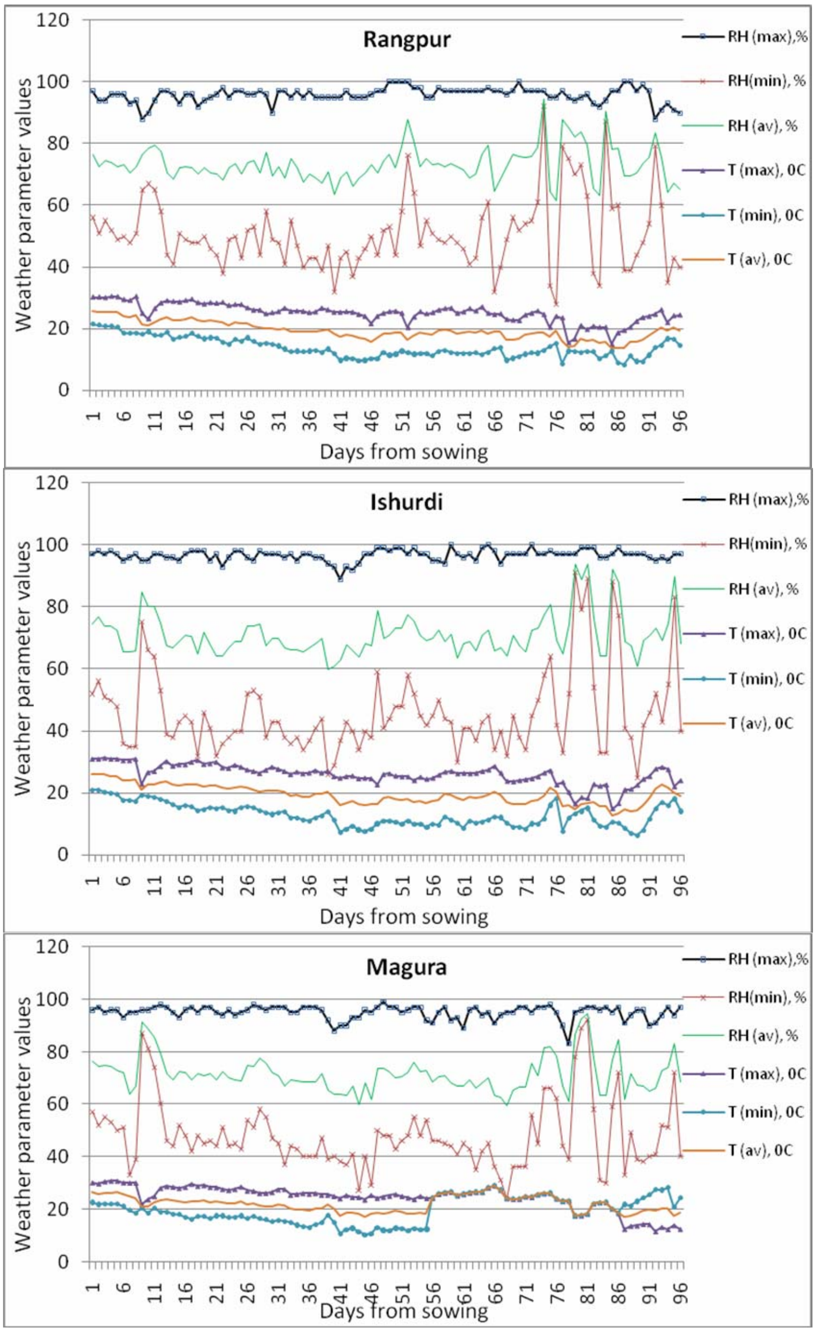

Fig. 1. Weather parameters of the sites during crop period (RH (max) = Maximum relative humidity, RH (min) = Minimum relative humidity, RH (av.) = Average relative humidity, T (max) = Maximum temperature, T (min) = Minimum temperature, T (av.) = Average temperature

Each plot was fertilized uniformly with basal dose of 80 kg P_2O_5 ha^{-1} as triple super phosphate, 60 kg K_2O ha^{-1} as muriate of potash, 80 kg N ha^{-1} as urea, 4 kg Zn ha^{-1} as zinc oxide and 20 kg S ha^{-1} as gypsum. Another 80 kg N ha^{-1} as urea was applied in two equal splits, one at active vegetative stage and another at flowering stage. The cultivars were sown at the rate of 7.5 kg ha^{-1} on 6, 7, and 8 November 2007 at Magura, Rangpur and Ishurdi, respectively, maintaining row spacing of 20 cm. At 15 days after sowing, plant spacing were maintained as 3 cm by thinning. Mustard was harvested manually on 10, 12 and 16 February 2008 at Ishurdi, Magura, and Rangpur, respectively.

Water balance components

Crop evapotranspiration was calculated from the general field water balance equation:

$$P + I + U = R + D \pm \Delta SM + ET \quad \text{………………………….} \ (1)$$

where,
- P = Effective rainfall
- I = Irrigation water applied
- U = Upward flux or capillary rise into the root zone
- R = Surface runoff from the plot
- D = Water lost by deep percolation
- ΔSM = Change in soil moisture storage in the soil profile
- ET = Evapotranspiration from cropped soil

All quantities are expressed in the same unit (in terms of volume of water per unit area, or equivalent depth units) during the period considered.

The sum of the terms on the left-hand side of the above equation represents the net addition of water to the soil profile over the time period of interest (sowing to physiological maturity). We assumed negligible upward flux (U) beyond the measured depth, since the level of the water table recorded in the observation well near the experimental field never got closer than 2.5 m from the soil surface. Surface runoff (R) was assumed zero as the land was flat and the plot was bounded by 30 cm height bunds. Deep percolation (D) was assumed negligible, since measured amount of water was applied considering root zone moisture deficit. Thus, equation (2) reduces to the following form to calculate ET:

$$ET = \quad I + P \pm \Delta SM \quad \text{……………..........} \ (2)$$

Soil moisture measurement

Soil moisture in each experimental plot of one row was measured by neutron probe (model 3320). Total soil moisture within the root zone at a particular time was calculated as:

$$SM_t = \sum_{i=1}^{n} (V_{wi} \times Z_i) / 100 \quad \text{...} (3)$$

where,

SM_t = Total profile soil moisture within the crop root zone, in m depth

V_{vi} = Volumetric moisture content in per cent for the layer *i*

Z_2 = Depth of soil layer *i*

n = Total number of soil layers within the root zone

Irrigation treatments were imposed as per schedule. Other cultural practices (such as weeding, thinning, etc.) were followed as and when necessary. Rainfall data were collected for all locations from the nearby meteorological stations.

Irrigation water Productivity

Irrigation water productivity (IWP) was calculated as:

$$\text{IWP} = \frac{Y_{seed}}{IW} \quad \text{..............................} (4)$$

Where Y_{seed} is the seed yield, and IW is the irrigation water applied.

Water productivity

Water productivity (WP) was calculated as:

$$\text{WP} = \frac{Y_{seed}}{ET} \quad \text{..............................} (5)$$

Where Y_{seed} is the seed yield, and ET is the crop evapo-transpiration.

Statistical analysis

The analysis of variance (ANOVA) was measured on the data for each parameter as applicable to the design. The significance of the treatment effect was determined using F-test, and to determine the significant difference among the means of the treatments, least significant difference (LSD) were estimated at 5% probability level.

Results and Discussion

(a) Ishurdi:

Impact of irrigation on yield attributes, seed and straw yield

The results revealed that irrigation schedules had significant effect on yield attributes such as plant height and number of branch plant^{-1}, and insignificant effect on other attributes like number of siliquae plant^{-1}, seed siliquae^{-1} and 1000 seed weight (Table 1).

Irrigation schedules had significant effect on both of seed and straw yield. Irrigation schedule based on irrigation at vegetative and flowering stages (T_3) produced the highest seed yield (1092 kg ha^{-1}). In case of seed yield, the effects of irrigation schedules except T_3 were statistically similar (Table 1). The second-highest seed yield (960 kg ha^{-1}) was produced with irrigation schedule based on irrigation at vegetative stage (T_1).

Table 1. Mean effect of irrigation and mutant lines on yield and yield attributing characters of mustard at BINA sub-station, Ishurdi

Treatments	Plant height (cm)	Branches plant^{-1} (no.)	Siliquae plant^{-1} (no.)	Seeds siliqua^{-1} (no.)	1000-seed weight (g)	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_0	85.4	1.6	51.4	25.8	3.7	874	1935
T_1	95.1	2.1	58.8	26.1	3.6	960	2098
T_2	86.1	1.5	52.2	25.8	3.6	906	2129
T_3	99.1	2.3	71.1	25.6	3.5	1092	2380
LSD $_{0.05}$	8.42	0.13	NS	NS	NS	89	179
V_1	90.4	1.3	41.6	20.2	3.4	849	2064
V_2	94.2	2.4	74.7	28.4	3.7	1067	2217
V_3	89.1	1.9	58.9	28.7	3.7	956	2127
LSD $_{0.05}$	NS	0.44	17.7	0.92	0.094	95	NS

Note: NS = Not significant

In case of straw yield, similar to that of seed yield, the treatment T_3 produced the highest straw yield (2380 kg ha^{-1}). In contrast to that of seed yield, the schedule based on irrigation at flowering stage produced the second highest straw yield (2129 kg ha^{-1}). The results may be explained by the fact that irrigation application at flowering stage delays the plant senescence and slow down the assimilate partitioning from vegetative part to seed; thus, lower seed yield and higher straw yield (Zhang and Yang, 2004).

Impact of irrigation on mutants/variety

The cultivars showed significant impact on seed yield and yield attributes except plant height and straw yield (Table 1). The highest seed yield was observed in V_2 (1067 kg ha^{-1}) followed by V_3 (956 kg ha^{-1}). The straw yield also followed similar trend.

Impact of irrigation on water balance components and water productivity

Irrigation regimes showed higher soil moisture extraction (Table 2), which might be due to normal/optimal development of root system. Total water use (ET) was the highest in 2-irrigation regime (T_3). Irrigation water productivity (IWP) was higher in single irrigation regimes (T_1 and T_2) compared to 2-irrigation regime (T_3), which might be due to increased crop water use without a corresponding increase in the yield. Between one irrigation regimes, irrigation at vegetative stage (T_1) showed higher IWP. Water productivity (WP) was the highest in non-irrigated regime (T_0), which might be due to efficient use of soil moisture under stress condition. However, the increased WP alone did not bring any significance if it was not associated with reasonable or optimum yield. The 2-irrigation regime (T_3) produced the second highest WP, which might be due to higher yield under optimum irrigation, compared to other irrigation regimes.

Table 2. Amount of irrigation water requirement and water productivity of mustard at BINA sub-station, Ishurdi

Treatments	Irrigation water (cm)	Effective rainfall (cm)	Soil moisture depletion, ΔS (cm)	Total water use (ET) (cm)	Seed yield (kg ha^{-1})	Irrigation water productivity (kg ha^{-1} cm^{-1})
T_0	0	4.32	9.39	13.89	874	-
T_1	3.2	4.32	10.65	18.35	960	300.0
T_2	4.16	4.32	9.16	17.82	906	217.8
T_3	5.08	4.32	10.07	19.65	1092	215.0

(b) Magura:

Impact of irrigation on yield attributes, seed and straw yield

Irrigation schedules showed insignificant effect on all yield attributes except 1000 seed weight, but showed significant effect on seed yield (Table 3). Positive response of irrigation on number of branch plant^{-1} and 1000 seed weight may contribute to significant yield difference. Irrigation at vegetative and flowering stages (T_3) produced the highest seed yield, but statistically similar with one irrigation regimes (T_1 and T_2). This may be due to significant amount of rainfall (total 111 mm) during the growing period.

Table 3. Mean effect of irrigation and mutant lines on yield and yield attributing characters of mustard at BINA sub-station, Magura

Treatments	Plant height (cm)	Branches plant^{-1} (no.)	Siliquae plant^{-1} (no.)	Seeds siliqua^{-1} (no.)	1000-seed weight (g)	Seed yield (kg ha^{-1})
T_0	101	2.8	42.1	24.5	2.6	510
T_1	100	3.2	49.4	26.0	2.8	848
T_2	106	3.2	52.6	24.6	2.8	876
T_3	105	3.3	47.5	25.5	2.9	961
$LSD_{0.05}$	NS	NS	NS	NS	0.14	184
V_1	106	5.1	44.6	22.8	2.9	467
V_2	100	2.1	47.6	26.8	2.7	987
V_3	103	2.2	51.4	25.9	2.8	942
$LSD_{0.05}$	4.29	0.44	NS	1.8	0.067	163

Note: NS = Not significant

Impact of irrigation on mutants/variety

The cultivars showed significant impact on yield and yield attributes except number of siliquae per plant (Table 3). The highest seed yield was observed in V_2 (987 kg ha^{-1}) followed by V_3 (942 kg ha^{-1}) which was similar to that of Ishurdi location.

Impact of irrigation on water productivity

Irrigation water productivity (IWP) was higher in a single irrigation regime (T_1 and T_2) compared to 2-irrigation regime (T_3) (Table 4). This might be due to efficient use of irrigation water. Water productivity (WP) was the lowest in non-irrigated regime (T_0). The 2-irrigation regime (T_3) produced the highest WP, which might be due to higher yield under optimum irrigation compared to other irrigation regimes.

Table 4. Amount of irrigation water requirement and water productivity of mustard at BINA sub-station, Magura

Treatments	Irrigation water (cm)	Effective rainfall (cm)	Soil Moisture Depletion (cm)	Total water use (ET) (cm)	Seed yield (kg ha^{-1})	Irrigation water productivity (kg ha^{-1} cm)	Water productivity, WP (kg ha^{-1} cm^{-1})
T_0	0	8.8	5.3	14.18	510	-	36.0
T_1	1.4	8.8	6.6	16.88	848	605.7	50.2
T_2	1.8	8.8	6.1	16.78	876	486.7	52.2
T_3	2.7	8.8	5.5	17.08	961	355.9	56.3

(c) Rangpur

Impact of irrigation on yield attributes, seed and straw yield

Yield and yield attributing characters were not significantly influenced by the irrigation regimes, but the straw yield was significantly affected (Table 5). Irrigation at vegetative and flowering stages (T_3) produced the highest seed yield (1628 kg ha^{-1}). The similar trend was also observed in case of straw yield.

Impact of irrigation on mutants/variety

The cultivars showed insignificant impact on yield and yield attributes except 1000 seed weight (Table 5). The highest seed yield was observed in V_2 (1654 kg ha^{-1}) followed by V_1 (1512 kg ha^{-1}). The highest straw yield was observed in V_1 (3073 kg ha^{-1}) followed by V_2 (2802 kg ha^{-1}).

Table 5. Mean effect of irrigation and mutant lines on yield and yield attributing characters of mustard at BINA sub-station, Rangpur

Treatments	Plant height (cm)	Siliquae $plant^{-1}$ (no.)	Seeds $siliqua^{-1}$ (no.)	1000-seed weight (g)	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_0	97.2	93.9	27.6	3.4	1330	2652
T_1	100.6	85.6	25.7	3.4	1392	2861
T_2	96.3	103.2	26.7	3.3	1553	2930
T3	99.2	106.6	26.3	3.3	1628	3083
$LSD_{0.05}$	NS	NS	NS	NS	NS	206
V_1	98.5	88.7	25.2	2.7	1512	3073
V_2	99.0	105.4	26.9	3.6	1654	2802
V_3	97.5	97.8	27.7	3.7	1335	2771
$LSD_{0.05}$	NS	NS	NS	0.11	NS	NS

Note: NS = Not significant

Impact of irrigation on ET and water productivity

Total water use (ET) was the highest in 2-irrigation regime (T_3) (Table 6). Irrigation water productivity (IWP) was higher in single irrigation regimes (T_1 and T_2) compared to 2-irrigation regime (T_3). Water productivity (WP) was the highest in non-irrigated regime (T_0). The single irrigation at vegetative stage (T_1) produced the second highest WP, which might be due to efficient water use compared to 2-irrigation regime.

Table 6. Amount of irrigation water used and water productivity of mustard at BINA sub-station, Rangpur

Treatments	Irrigation water (cm)	Effective rainfall (cm)	Soil moisture depletion, ΔSM (cm)	Total water use (ET) (cm)	Seed yield (kg ha^{-1})	Irrigation water productivity (kg ha^{-1} cm)	Water productivity (kg ha^{-1} cm^{-1})
T_0	0	2.88	3.1	6.02	1330	-	220.9
T_1	3.0	2.88	4.5	10.38	1392	464.0	134.1
T_2	4.11	2.88	4.6	11.59	1553	377.9	134.0
T_3	5.17	2.88	3.3	12.35	1628	314.8	131.8

Comparison over locations

In all locations, the highest seed yield was observed with 2-irrigation regime (T_3). In case of second highest seed yield (which occurred with single- irrigation regimes), it occurred with irrigation at vegetative stage (20–25 DAS) at Ishurdi but with irrigation at flowering stage at Magura and Rangpur. This might be due to the combined effects of soil moisture reserved, weather condition (ET demand and rainfall) and advective energy at vegetative as well as flowering stages (Kar *et al.*, 2007; Mandal *et al.*, 2006). Over the locations, the lowest yield was produced at Magura.

Conclusion

From the study, although the highest seed yield was observed with 2-irrigation regime at all locations, but it was statistically similar with single-irrigation regime (irrigation at vegetative or at flowering). The increase in yield in 2-irrigation regimes compared to single irrigation regime ranged from 13.3% to 17.0%, but the irrigation water productivity decreased. Considering the irrigation water use, yield and irrigation water productivity, it could be concluded that for the highest seed yield, mustard should be irrigated twice, namely at vegetative and flowering stages. In view of the limited water supply situations (considering water economy), specially where groundwater withdrawal causes ecological inbalance, mustard should be irrigated only at vegetative stage for optimum yield.

References

BBS, 2009. Yearbook of Bangladesh. Agricultural Statistics of 2011. Bangladesh Bureau of Statistics, Statistics Division, Ministry of Planning, the Peoples Republic of Bangladesh. July, 2011. p. 101.

Ehesanullah, M., Prasad, U. K. and Prasad, T. N. 1991. Effect of irrigation and nitrogen on yield and yield functional relationships and economics of mustard. Indian J. Agron., 36: 150-152.

Kar, G., Kumar, A., Martha, M. 2007. Water use efficiency and crop coefficient of dry season oilseed crops. Agric. Water Manage., 87: 73-82.

Mandal, K. G., Hati, K. M., Misra, A. K., Bandyopadhyay, K. K. 2006. Assessment of irrigation and nutrient effects on growth, yield and Water use Efficiency of Indian mustard in central India.

Parihar, S. S. 1991. Effects of nitrogen and irrigation on mustard (*Brassica juncea*). Indian J. Agron., 36: 156-159.

Sarkar, A. A., Ali, S. M. A., Talukdar, M. S. U. and Ahmed, M. 1991. Irrigation scheduling of mustard using open pan evaporation. Pak. J. Sci. Ind Res., 34: 191-195.

Zhang, J. and Yang, J. 2004. Improving harvest index is an effective way to increase crop water use efficiency. *In*: Proc., 4^{th} Int. Crop Sci. Congress, held at Brisbane, Sept. 2004, on the theme “Crop Science for Diversified Planet”.

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EVALUATION OF SOME CHICKPEA MUTANTS AND VARIETIES AGAINST CUTWORM AND POD BORER AT TWO LOCATIONS OF BANGLADESH

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Abstract

Field trials on chickpea genotypes (P-70, CPC-830, BARI Chola-5 and Binasola-4) were conducted at two locations (Rajshahi and Jamalpur) of Bangladesh under pesticide free field conditions to find out their resistance or susceptibility against cutworm and pod borer infestation. The genotypes were different, considering physiomorphic characters at both the locations. The highest number of branch plant^{-1} was observed on CPC-860 (9.01) and the lowest was on P-70 (8.51) at 35 days after sowing (DAS). The highest trichome density cm^{-2} of pod shell was observed on CPC-860 (238.33) and the lowest was on Binasola-4 (185.16). Number of cut plant by cutworm did not vary significantly among the genotypes. However, the highest number of cut plant was observed on P-70 (8.33) and the lowest was on CPC-860 (7.33) and Binasola-4 (7.33) at 30 days after sowing. Total pods plant^{-1} were not significantly different among the genotypes. The percentage of pod infestation varied significantly among the different genotypes. The highest percentage of pod infestation was observed on P-70 (10.91%) and the lowest was on CPC-860 (7.08%). Hundred seed weight and seed yield varied significantly among the genotypes. The highest 100 seed weight was observed in CPC-860 (26.56 g) in Jamalpur and the lowest was on Binasola-4 (12.93 g) in Rajshahi. Similarly, the highest seed yield was obtained from CPC-860 (1904 kg ha^{-1}) in Jamalpur and the lowest was from Binasola-4 (1552 kg ha^{-1}) Rajshahi. Positive and significant relationship of pod borer infestation with the number of branch plant^{-1} was observed but negative relationship was found with the number of trichome on pod shells. Thus, the results clearly suggested that chickpea pod borer infestation increased with the increase of total branch plant^{-1}, while the higher number of trichome on pod shell reduced the pod borer infestation. However, CPC-860 was found as the best one against cutworm and pod borer infestation.

Key Words: Cutworm, Pod borer, Chickpea genotypes

Introduction

In Bangladesh, chickpea (*Cicer arietinum* L.) is the third major pulse crop after grass pea and lentil (Islam *et al.,* 1987; Anonymous, 1987) grown during the winter season (Ali *et al.,* 2003). Chickpea occupied 37,000 acres of cultivated land in 2009-'10,

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which produced 11,000 tons, while the average yield estimated 29 ton $acre^{-1}$ (BBS, 2011). Chickpea is attacked by 10 different insect pests (Baka, 1998) causing 10-15% yield loss (Kay, 1979). Among the insect pests, pod borer and cutworm have been identified as the major pests of chickpea (Saxena, 1978) both of which are polyphagous in nature (Alam and Ahmad, 1975; Das, 1994). The larvae of cutworm cause damage to the chickpea plant by cutting the stem at the base or leaflets in seedling stage. A single larva of cutworm is capable of damaging several seedlings in one night and a large population can destroy large number of plants (seedlings). The damage potential of pod borer has been proved its acceptance as the most serious pest of chickpea and of prime importance in agricultural research.

In recent years, efforts are being made to increase per acre yield of pulse crop in Bangladesh by adopting different improved agronomic practices and technology such as the use of better seeds of high yielding variety, fertilizers, improved cultivation practices, irrigation and drainage. But the production is hampered seriously if effective control measures are not taken to control insect pests of chickpea. Among different control methods, use of resistant cultivars is the most effective one for preventing the infestation of pod borer and cutworm. On the other hand, intensive use of conventional insecticides on a wide variety of crops has led to widespread development of insecticide resistant populations of pod borer (Armes *et al.*, 1996). Because of development of insect resistance to insecticide, huge amount of insecticide is needed to use resulting high cost of production and other possible adverse effects on environmental degradation, ecological imbalance, residual problems in food, pollution to water, air, soil, human exposure, etc. These phenomena have stimulated interest on other methods for finding out the resistant genotypes or mutant/variety to manage pod borer and cutworm (Lateef, 1985).

The present study was aimed to evaluate some chickpea genotypes developed by BINA against the attack of cutworm, *Agrotis ipsilon* and pod borer, *Helicoverpa armigera* at two chickpea growing locations of Bangladesh with the following objectives:

1. To determine the possible variation of cutworm and pod borer infestation on some chickpea genotypes grown at two locations (Rajshahi and Jamalpur) of Bangladesh; and
2. To identify the resistant or tolerant chickpea genotypes or varieties against cutworm and pod borer.

Materials and Methods

The experiment was conducted at farmer’s field in Godagari under the district of Rajshahi and substation farm of BINA located at sadar upzila under the district of Jamalpur during the period from November 2011 to April 2012. The land of the experimental fields at both locations was ploughed with the power tiller followed by laddering to obtain desirable tilth. Whole experimental land was divided into unit plots maintaining the desired spacing. The size of the unit plot was 5 m length and 4 m width. Block to block and plot to plot distances were 1.0 m and 0.5 m, respectively. Total area of a whole experimental field was 240 m^2. The experiment was conducted in randomized complete block design (RCBD) with 3 replications at both the locations of Rajshahi and Jamalpur. Two mutants (P-70 and CPC-830) and two check varieties (Binasola-4 and BARI Chola-5) were used to study their resistance or susceptibility against cutworms and pod borer. Seeds of all varieties and mutants were collected from Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh. Germination test was performed in the laboratory before sowing the seeds in the field. The seeds were sown in rows maintaining row to row and seed to seed 30 cm and 15 cm distance, respectively having two seeds in each point. All the necessary intercultural operations were done as and when required. Number of cut plant by cutworm $plot^{-1}$ at 25 DAS and 30 DAS were counted at the both locations. Before harvesting the crops, 10 representative plant samples from each plot were collected separately, tagged properly and brought to the laboratory for further observations. The plots were harvested separately at about 80% pod maturity. The maturity dates were different among the varieties and mutants. The dates of maturity ranged from 116-125 days. The harvested crops were brought to the threshing floor and dried in the sun properly. The seeds were threshed out of the pod with the help of hands and stick. Seed and straw yield was recorded plot wise after drying. After the collection of plant samples of different genotypes from the experimental field, the following physiomorphic parameters were studied in the laboratories. Yield and yield attributes of chickpea genotypes and varieties, percent of alive plants, percent of dead plants, number of leaves $branch^{-1}$, number of branch $plant^{-1}$, number of flower $plant^{-1}$, number of pod $plant^{-1}$, number of pod infestation $plant^{-1}$, percent pod infestation, trichomes density cm^{-2} pod shell, 100 grain weight (g) and yield (kg ha^{-1}) were determined. Analysis of variance was done with the help of computer package MSTAT-C developed by Russell (1986). The mean comparisons of the treatments were evaluated by DMRT (Duncan's Multiple Range Test) to indicate the level of significance.

Results and Discussion

Percentage of alive plant, dead plant and number of leaf $plant^{-1}$

Combined effect of genotype and location on per cent of alive plant, dead plant and number of leaf $plant^{-1}$ is presented in the Table 1. Results indicated that there were significant variations in per cent of alive plant among the genotypes both at Rajshahi and Jamalpur while the other two parameters were not.

Table 1. Combined effect of genotypes and locations on per cent of alive plant, dead plant and number of leaf plant^{-1}

Treatments	% alive plants		% dead plants		Number of leaves plant^{-1}	
Varieties/mutants	Jamalpur	Rajshahi	Jamalpur	Rajshahi	Jamalpur	Rajshahi
BARI Chola-5	70.32 ab	61.86 b	22.28	38.12	132.00	132.33
P-70	73.87 a	74.77 a	37.80	36.21	139.33	138.66
CPC-860	77.48 a	76.33 a	23.39	23.72	142.00	151.33
Binasola-4	68.54 ab	64.60 b	28.01	30.83	130.66	135.33
CV (%)	6.74		30.46		5.33	
LSD	8.37					
Level of significance	**					

Different letters within a column indicate the significantly difference and **stands for significant at 5% level of probability.

The highest per cent of alive plant was recorded on CPC-860 (76.33) followed by P-70 (74.77) and the lowest was on BARI Chola-5 (61.86) followed by Binasola-4 (64.60) at Rajshahi. In Jamalpur, the highest per cent of alive plant was recorded on CPC-860 (77.48) followed by P-70 (73.87) and the lowest was on Binasola-4 (68.54) followed by BARI Chola-5 (70.32). The highest per cent of dead plant was observed on BARI Chola-5 (38.12) and the lowest was on CPC-860 (23.72) at Rajshahi. But at Jamalpur, the highest per cent of dead plant was recorded on P-70 (37.80) and the lowest was on BARI Chola-5 (22.28). The highest number of leaf plant^{-1} was observed on CPC-860 (151.33) and the lowest was on BARI Chola-5 (132.33) at Rajshahi. The highest number of leaf plant^{-1} was recorded on CPC-860 (142.00) and the lowest was on Binasola-4 (130.66) at Jamalpur.

Number of branch plant^{-1}, number of flower plant^{-1} and trichome density cm^{-2} of pod shell

Combined effect of genotypes and locations on number of branch plant^{-1}, number of flower plant^{-1}, and trichome density cm^{-2} of pod shell is presented in Table 2. Results showed that there were no significant variations among the genotypes in different aspects of the plant at Rajshahi and Jamalpur. However, relatively higher number of branch plant^{-1} was observed on BARI Chola-5 (5.50) and the lower was on Binasola-4 (4.90) at Rajshahi at 25 DAS.

At Jamalpur, the highest number of branch plant^{-1} was observed on BARI Chola-5 (5.73) and the lowest was on CPC-860 (4.86) at 25 DAS. The highest number of branch plant^{-1} was observed on CPC-860 (9.10) and the lowest was on P-70 (8.51) at Rajshahi at 35 DAS. At Jamalpur, the highest number of branch plant^{-1} was observed on CPC-860 (8.94) and the lowest was on BARI Chola-5 (8.50) at 35 DAS. The highest number of flower plant^{-1} was recorded on CPC-860 (68.13) and the lowest was on P-70 (54.63) at Rajshahi. The highest number of flower plant^{-1} was found on CPC-860 (69.46) and the

Table 2. Combined effect of genotypes and locations on number of branch plant^{-1}, number of flower plant^{-1} and trichome density cm^{-2} of pod shell

Treatments		Number of branches plant^{-1}		Number of flowers plant^{-1}	Trichome density cm^{-2} of pod shell
Locations	Varieties/mutants	25 DAS	35 DAS		
Rajshahi	BARI Chola-5	5.50	8.89	66.16	234.66
	P-70	5.06	8.51	54.63	187.66
	CPC-860	5.03	9.10	68.13	239.33
	Binasola-4	4.90	8.54	60.16	223.66
Jamalpur	BARI Chola-5	5.73	8.50	57.93	231.66
	P-70	5.03	8.90	55.56	182.66
	CPC-860	4.86	8.94	69.46	237.33
	Binasola-4	5.53	8.78	57.66	219.33
CV (%)		7.07	6.19	9.26	1.05

lowest was on P-70 (55.56) at Jamalpur. The highest number of trichome density cm^{-2} of pod shell was observed on CPC-860 and the lowest was on P-70 at Rajshahi and Jamalpur. The above variability in the number of branch is in partial agreement with Gupta *et al.* (1995) and they reported that the number of branch plant^{-1} ranged from 9.01 to 10.88. Pod borer infestation increased with the increase of branch plant^{-1} because it makes a plant bushy but yield is increased.

Number of cut plant by cutworm plot^{-1}

Combined effect on number of cut plant by cutworm plot^{-1} at 25 DAS and 30 DAS, is shown in Table 3. Results indicated that there were no significant variations among the genotypes and locations. The maximum number of cut plant by cutworm plot^{-1} was found on P-70 (5.66) and the minimum was on BARI Chola-5 and Binasola-4 (5.00) at 25 DAS at Rajshahi.

Table 3. Combined effect of genotypes and locations on number of cut plant by cutworm plot^{-1}

Treatments		Number of cut plants by cutworm plot^{-1}	
Locations	Varieties/mutants	25 DAS	30 DAS
Rajshahi	BARI Chola-5	5.00	8.00
	P-70	5.66	8.33
	CPC-860	5.33	7.66
	Binasola-4	5.00	8.00
Jamalpur	BARI Chola-5	5.00	8.33
	P-70	6.00	8.66
	CPC-860	5.00	6.66
	Binasola-4	4.66	6.66
CV (%)		16.76	15.97

Total pod plant^{-1} and infested pod plant^{-1}

Number of infested pod plant^{-1} is an important factor of yield loss. Combined effect of genotypes and locations on total pod plant^{-1} and infested pod plant^{-1} at 90 DAS and 95 DAS is shown in Table 4. Results showed that there were significant variations in total pod plant^{-1} at 90 DAS and 95 DAS among the genotypes both at Rajshahi and Jamalpur. At 90 DAS, the highest total pod plant^{-1} was observed on CPC-860 (56.00) followed by Binasola-4 (54.66) and the lowest was on P-70 (42.33) at Rajshahi. The highest total pod plant^{-1} at 90 DAS was observed on CPC-860 (53.33) and the lowest was on Binasola-4 (48.33) at Jamalpur. At 95 DAS, the highest total pod plant^{-1} was observed on CPC-860 (56.67) followed by Binasola-4 (55.33) and the lowest was on P-70 (44.00) at Rajshahi. The highest total pod plant^{-1} at 95 DAS was observed on CPC-860 (58.67) and the lowest was on BARI Chola-5 (50.33) followed by Binasola-4 (50.67) at Jamalpur.

Table 4. Combined effect of genotypes and locations on total pod plant^{-1} and infested pod plant^{-1}

	Treatments	Total pod plant^{-1}		Infested pod plant^{-1}	
Locations	Varieties/mutants	90 DAS	95 DAS	90 DAS	95 DAS
Rajshahi	BARI Chola-5	46.66 ab	48.00 bc	4.26	4.73
	P-70	42.33 b	44.00 c	6.30	6.70
	CPC-860	56.00 a	56.67 ab	4.23	4.63
	Binasola-4	54.66 a	55.33 ab	5.13	5.66
Jamalpur	BARI Chola-5	50.00 ab	50.33 abc	4.26	5.26
	P-70	51.66 ab	54.00 ab	5.06	6.06
	CPC-860	53.33 a	58.67 a	3.40	4.93
	Binasola-4	48.33 ab	50.67 abc	3.10	5.76
CV (%)		10.25	9.34	27.26	20.81
LSD		9.03	8.54		
Level of significance		**	**		

Different letters within a column indicate the significant difference and **stands for significant at 5% level of probability.

The highest infested pod plant^{-1} at 90 DAS was observed on P-70 (6.30) and the lowest was on CPC-860 (4.23) at Rajshahi. The highest infested pod plant^{-1} at 90 DAS was observed on P-70 (5.06) and the lowest was on Binasola-4 (3.10) at Jamalpur. The highest infested pod plant^{-1} at 95 DAS was observed on P-70 (6.70) and the lowest was on CPC-860 (4.63) at Rajshahi. The highest infested pod plant^{-1} at 95 DAS was observed on P-70 (6.06) and the lowest was on CPC-860 (4.93) at Jamalpur. Results revealed that there were no significant variations in number of infested pod plant^{-1} at 90 DAS and 95 DAS among the genotypes both at Rajshahi and Jamalpur. The total number of pods plant^{-1} among the genotypes ranged from 42.33 to 56.00 and 44.00 to 56.67 at Rajshahi and 50.00-53.33 and 50.33 to 58.67 at Jamalpur at 90 DAS and 95 DAS, respectively. The infested pod plant^{-1}

among the genotypes ranged from 4.23 to 6.30 and 4.63 to 6.70 at Rajshahi and 3.10 to 5.06 and 4.93 to 6.06 at Jamalpur at 90 DAS and 95 DAS, respectively. These results are similar with the findings of Asewar *et al.* (2003), where total number of pods plant^{-1} ranged from 37.81 to 62.76 in chickpea.

Per cent pod infestation

Combined effect of genotypes and locations on per cent of pod infestation at 90 DAS and 95 DAS is presented in Table 5. Results indicated that there were significant variations in per cent of pod infestation at 90 DAS and 95 DAS among the genotypes both at Rajshahi and Jamalpur. The highest per cent pod infestation at 90 DAS was observed on BARI Chola-5 (10.97) followed by P-70 (10.69) and the lowest was on CPC-860 (7.46) followed by Binasola-4 (7.53) at Rajshahi. The highest per cent pod infestation at 90 DAS was observed on P-70 (8.40) and the lowest was on CPC-860 (6.43) followed by Binasola-4 (6.82) and BARI Chola-5 (7.98) at Jamalpur. The highest per cent pod infestation at 95 DAS was observed on P-70 (13.49) followed by BARI Chola-5 (12.13) and the lowest was on CPC-860 (7.55) followed by Binasola-4 (7.73) at Rajshahi.

Table 5. Combined effect of genotypes and locations on per cent pod infestation

Treatments		Pod infestation (%)	
Locations	Varieties/mutants	90 DAS	95 DAS
Rajshahi	BARI Chola-5	10.97 a	12.13 a
	P-70	10.69 a	13.49 a
	CPC-860	7.46 b	7.55 b
	Binasola-4	7.53 b	7.73 b
Jamalpur	BARI Chola-5	7.98 b	11.05 a
	P-70	8.40 ab	11.42 a
	CPC-860	6.43 b	9.70 ab
	Binasola-4	6.82 b	10.33 ab
CV (%)		23.82	16.27
LSD		3.74	2.77
Level of significance		***	***

Different letters within a column indicate the significant difference and ***stands for significant at 1% level of probability.

The highest per cent pod infestation at 95 DAS was observed on P-70 (11.42) followed by BARI Chola-5 (11.05) and the lowest was on CPC-860 (9.70) followed by Binasola-4 (10.33) at Jamalpur. The present results are more or similar with some other previous reports. Sanap and Jamadagni (2005) reported that the mean damage of pods plant^{-1} of twenty five chickpea genotypes ranged from 25.51% ± 3.61%. Bhatt and Patel (2001) recorded the lowest pod damage (9.55%) by *Helicoverpa armigera* in Chaffa chickpea cultivars. Mandal (2003) reported that pod damage varied from 9.43 to 24.80% in chickpea.

Hundred seed weight and seed yield of chickpea

Combined effect on 100 seed weight (g) and seed yield plot^{-1} (kg ha^{-1}) is shown in Table 6. The maximum 100 seed weight (g) was recorded in CPC-860 and the minimum was in Binasola-4 both at Rajshahi and Jamalpur. The highest yield (kg ha^{-1}) was found on CPC-860 (1815 kg ha^{-1}) and the lowest was in Binasola-4 (1552 kg ha^{-1}) at Rajshahi. No significant difference was observed in 100 seed weight of the different genotypes.

Table 6. Combined effect of genotypes and locations on 100 seed weight and yield

Treatments		100 seed weight (g)	Yield (kg ha^{-1})
Locations	Varieties/mutants		
Rajshahi	BARI Chola-5	14.50	1740
	P-70	25.63	1794
	CPC-860	25.93	1815
	Binasola-4	12.93	1552
Jamalpur	BARI Chola-5	14.66	1760
	P-70	25.80	1805
	CPC-860	26.56	1904
	Binasola-4	13.03	1567
CV (%)		2.17	2.85

These results are similar with the findings of Gupta *et al.* (1996) and they reported that 100 grain weight ranged from 11.23 to 17.5 g.

Conclusion

From the results, it could be concluded that no chickpea genotypes were 100% resistant against cutworm and pod borer infestations. However, CPC-860 showed the highest performance regarding leaf plant^{-1}, branch plant^{-1}, trichome density on pod surface and yield and the lowest cut plant by cutworm plot^{-1} and per cent pod infestation. Further, research with these chickpea genotypes at some more locations of Bangladesh and also at artificial conditions might be done for confirmation of the achieved results.

References

Alam, M.Z. and Ahmad, A. 1975. Control of cutworm in potato. Bangladesh Hort., 3(1): 51.

Ali, M. Y., Johansen, C. and Ahmed, S. 2003. Annigeri in the High Barind Tract of Bangladesh-performance of a chickpea variety out of its zone of adaptation. Int. Chickpea and Pigeon Pea Newsl., 10: 16-17.

Anonymous. 1987. Statistical Year Book of Bangladesh. Bangladesh Bureau of Statistics, Statistics Div., Ministry of Planning, Govt. of the People's Republic of Bangladesh, pp. 61-64.

Armes, N. J., Jadhav, D. R. and Desouza, K. R. 1996. A survey of insecticide resistance in *Helicoverpa armigera* in the Indian Sub-continent. Bull. Entomological Res., 86: 499-514.

Asewar, B. V., Bairade, S. S., Kohire, D. D. and Bairade, P. S. 2003. Integrated use of vermicompost and inorganic fertilizer in chickpea. Annals. Pl. Physiol., 17(2): 205-206.

Baka, M. A. 1998. Diseases and insect pest management of mungbean and black gram. In: Resource manual Location Specific technologies for rice based cropping systems under irrigated conditions. Thana Central Technology Transfer and Identification Project. Dhaka, pp. 201-205

BBS, 2011. Monthly Statistical Bulletin, Bangladesh Bureau of Statistics. Stat. Div. Min. Plan. Govt. of the People's Republic of Bangladesh, Dhaka, p. 67.

Bhatt, N. J. and Patel, R. K. 2001. Screening of chickpea cultivars for their resistance to gram pod borer, *Helicoverpa armigera.* Indian J. Entomol., 63(3): 277-280.

Das, G. P. 1994. Potato cutworm and its management (in Bengali). Technical Bulletin. Tuber Crops Research Centre, BARI, Joydebpur, Gazipur, p. 9.

Gupta, P. K., Sing, K., Sing, U. N., Sing, R. N. and Bohra, J. S. 1996. Effect of moisture regimes and fertility level on growth, yield, nutrient turnover and moisture use by French bean *(Phaseolus vulgaris).* Indian J. Agric. Sci., 66(6): 343-347.

Gupta S. N., Dhaiya, B. S., Malik, B. P. S. and Bishnoi, N. R. 1995. Research of Chickpea to water deficits and drought stress. Haryana Agric. University J. Res., 25(1&2): 11-19.

Islam, M. Q., Sarker, A. T., Quader, M. and Begum, K. 1987. Status of chickpea improvement at BARI. In Proc. National workshop on pluses at Joydebpur, Gazipur. eds., Kaul, A. K. 1982, pp. 56-64.

Kay, D. E. 1979. Food Legumes. Tropical products institute. Crop and Product digest No. 3, TPI London, pp. 27-31.

Lateef, S. S. 1985. Gram pod borer *(Helicoverpa armigera*) (Hub.) resistance in chickpeas. Agric. Ecosys. Environ., 14: 95-102.

Mandal, S. M. A. 2003. Screening of some chickpea genotypes against *Helicoverpa armigera.* Environ. Ecol., 21(1): 240-241.

Sanap, M. M. and Jamadagni, B. M. 2005. Screening of chickpea for resistance to pod borer *Helicoverpa armigera* (Hubner) at Rahuri, Maharashtra, India. Int. Chickpea and Pigeonpea Newsl., 12: 37-39.

Saxena, H. P. 1978. Pest of grain legumes and their control in India. *In:* S. R. Sing, H. F. van Emden and T.A. Taylor (eds.). Pest of Grain Legumes: Ecology and Control. Academic Press, London, pp. 15-23.

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EFFECTS OF SULPHUR, MAGNESIUM AND ZINC ON YIELD AND THEIR NUTRIENT UPTAKE BY T. AMAN RICE

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Abstract

A field experiment was conducted in the Old Brahmaputra Floodplain soil at the Bangladesh Institute of Nuclear Agriculture (BINA) farm, Mymensingh during Kharif season of 2012 with T. aman rice (cv. Binadhan-7) to evaluate the effects of sulphur, magnesium and zinc on the growth, yield and nutrient uptake. The experiment was laid out in a randomized complete block (RCBD) design with eight treatments in three replications. The eight treatments were T_1: NPK (control), T_2: S, T_3: Mg, T_4: Zn, T_5: S+Mg, T_6: S+Zn, T_7: Mg+Zn and T_8: S+Mg+Zn. All plots received an equal rate of N, P and K ($N_{80}P_{20}K_{40}$) to support normal plant growth. S, Mg and Zn were applied @ 10, 15 and 2 kg ha^{-1}, respectively. Source of N, P, K, S, Mg and Zn were urea, triple super phosphate, muriate of potash, gypsum, magnesium sulphate and zinc oxaide, respectively. The grain and straw yields of T. aman rice were significantly influenced due to application of S, Mg and Zn. Grain yield of T. aman rice varied from 3.13 to 5.52 t ha^{-1}, with the highest yield recorded in the treatment T_8 followed by T_5 treatment. S, Mg and Zn contents and their uptake by T. aman rice were affected significantly. The highest nutrients uptake by both grain and straw was obtained from the treatment T_8 and the lowest was obtained in control. The results revealed that S, Mg and Zn along with NPK are essential to obtain higher yield of T. aman rice than the application of NPK alone.

Key words: T. aman rice, Sulphur, Magnesium, Zinc, Nutrient uptake

Introduction

Rice (*Oryza sativa* L.), is one of the most important staple foods worldwide which is second (more than 153 million hectare) after wheat in terms of the acreage of cereal crops (FAO, 2012). It is the first cereal crop in Bangladesh (BBS, 2011). In total cultivable area of Bangladesh, rice covers 77.07% in which contribution of aman rice is 48.97% (BBS, 2011). Unfortunately, the average yield of rice in this country is low (4.2 t ha^{-1}) compared to other rice growing countries like Egypt (9.4 t ha^{-1}), China and South Korea (6.5 t ha^{-1}) and Vietnam (5.3 t ha^{-1}) (FAO, 2012). On the other hand, the demand for increasing rice production is mounting up to feed the ever-increasing population.

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Crop production is closely related to soil fertility. Fertile soil is the fundamental resources for higher crop production and supplies all mineral nutrients to the crops. The crop production system with high yield targets cannot be sustainable unless nutrient inputs to soil are at least balanced against nutrient removal by crops (Jahiruddin and Rijma, 2004). Consequently, in addition to N, P and K deficiencies with some other nutrients such as S, Mg (Samy *et al.*, 1992) and Zn deficiencies are being observed in many parts of the countries (Jahiruddin *et al.*, 1995). Deficiencies of sulphur in rice growing areas of Bangladesh have been well documented (Sakai, 1980). It was estimated that about 2.8 million hectares under rice suffered from sulfur deficiency (Khurana *et al.*, 2008).

Rice suffers from Mg deficiency in many locations and Mg application increased grain yield significantly in Guar and Hutan soils series (Choudhury and Khanif, 2001). Zinc is one of the most important micronutrients essential for plant growth especially for rice grown under submerged condition. Zinc deficiency under flooded condition has been studied by Fageria *et al.* (2011). Many literature claimed that application of S, Mg and Zn is essential to increase rice production in the country. Therefore, this study was undertaken to see the response of S, Mg and Zn fertilization on T. aman rice in Old Brahmaputra Floodplain soil.

Materials and Methods

The experiment was conducted at BINA headquarters farm, Mymensingh under the Old Brahmaputra Floodplain (AEZ 9) non-calcareous dark grey floodplain Sonatala silt loam soil during July to November 2012. T. aman rice (Binadhan-7) was used as test crop. Eight treatments combinations were used with S, Mg and Zn, such as T_1: NPK (control), T_2: S, T_3: Mg, T_4: Zn, T_5: S+Mg, T_6: S + Zn, T_7: Mg + Zn and T_8: S + Mg + Zn. S, Mg and Zn were applied @ 10, 15 and 2 kg ha^{-1} respectively. The experiment was conducted following RCBD with three replications for each treatment. A common basal dose of $N_{80}P_{20}K_{40}$ was applied to each plot (BARC, 2005). The source of N, P, K, S, Mg and Zn was urea, triple super phosphate, muriate of potash, gypsum, magnesium oxide and zinc oxide, respectively. Nitrogen was applied in three equal splits. One-third of urea was applied as basal to the individual plots during final land preparation. The second split of urea was applied 30 days after transplanting i.e., at maximum tillering stage and the remaining split at 55 days after panicle initiation stage. Intercultural operations were done as and when required. Supplementary irrigation was done as per requirement. Plant height, panicle length, grains $hill^{-1}$, number of tillers $hill^{-1}$ and 1000-grain weight were recorded when the crop attained at maturity. After harvesting the crop grain and straw yields were dried and weighted from each unit plot.

Initial soil samples were analyzed following standard method such as soil pH was determined by glass electrode pH meter (1 : 2.5 soil-water ratio), Particle-size distribution (%) was analyzed using the hydrometer method (Gee and Bauder, 1986), organic matter estimated by wet oxidation method (Nelson and Sommers, 1982), total nitrogen was determined by Kjeldahl method (Page *et al.,* 1982), available P was determined by Olsen method (Olsen *et al.,* 1954), available S was estimated by turbidity method (Page *et al.,* 1982) exchangeable K and Mg was determined by extraction with 1M NH_4OAc at pH 7 and their content were measured by flame photometer (Page *et al.,* 1982) available B was determined by the Hunter method (Hunter, 1984) and available Zn was extracted by DPTA method, measured by AAS. Characteristics of initial soil have been given in the Table 1. The nutrient uptake was calculated using the nutrient content of respective element in the plant samples.

The collected data were statistically analyzed to obtain the level of significance using MSTAT-C (Russel, 1986) and the means were separated by Duncan's Multiple Range Test (Gomez and Gomez, 1984).

Table 1. Characteristics of initial soil in the experimental field at BINA farm Mymensingh

Properties	Value	Interpretation*
Sand (%)	27.06	Silt loam
Silt (%)	63.6	
Clay (%)	9.64	
pH	6.5	Slightly acidic
Organic matter (%)	1.57	Medium
Total N (%)	0.098	Low
Available P (mg kg^{-1} soil)	13	Low
Exchangeable K (meq.100 g^{-1} soil)	0.10	Low
Available S (mg kg^{-1} soil)	12.1	Low
Exchangeable Ca (meq.100 g^{-1} soil)	3.87	Optimum
Exchangeable Mg (meq.100 g^{-1} soil)	0.67	low
Available Zn (mg kg^{-1} soil)	0.82	low
Available B (mg kg^{-1} soil)	0.23	low

* (BARC, 2005)

Results and Discussion

Yield components

The data on yield components of T. aman rice (Binadhan-7) as affected by different fertilizer treatments are presented in the Table 2. The plant height of T. aman rice was significantly affected due to the application of S, Mg and Zn (Table 3). The highest plant height (81.80 cm) was recorded with the treatment T_8 which was identical with the treatment T_5 and the lowest plant height (72.67 cm) was recorded in T_1 (control). However, all the treatments gave higher plant height than that of the control.

Significant effect was also found due to application of S, Mg and Zn on tillering of T. aman rice (Table 3). The highest number of tillers hill^{-1} (11) was observed when S, Mg and Zn applied in together (T_8), which was statistically identical with the treatments T_5 and T_6. The lowest numbers of tillers hill^{-1} (8.90) was noted in the control (T_1) treatment. Like plant height and tillers hill^{-1}, panicle length of T. aman rice was significantly influenced due to different treatments (Table 3). The panicle length varied from 19.4 cm in T_1 (control) treatment to 21.73 cm in T_8 treatment. However, the panicle length was significantly higher in all the treatments than that the control.

The number of grains panicle^{-1} was also significantly influenced due to different treatments (Table 2). The grains panicle^{-1} (no.) varied from 66.3 to 90.03. The highest grain panicle^{-1} (90.03) was recorded with treatment T_8 which was identical with T_5 and T_6 treatment and the lowest (66.3) was obtained in T_1.

The 1000-grain weight of T. aman rice was significantly affected due to the application of different treatments and varied from 21.28 to 22.93 g (Table 2). The treatment T_8 gave the highest 1000-grain weight followed by the treatment T_5 (22.75 g) but they were identical. The control treatment gave the lowest (21.28 g) 1000-grain weight.

Chande1 *et al.* (2003) reported that sulphur application improved plant height, leaf number and dry matter production and yield attributes of rice. Jawahar and Vaiyapuri (2010) found significant increase in plant height, number of tillers hill^{-1}, number of panicles m^{-2}, number of grains panicle^{-1} due to S fertilization in rice. Rahman *et al.* (2008) showed significant increase in plant height, number of effective tillers hill^{-1}, panicle length, number of grains panicle^{-1} and 1000-seed weight due to S and Zn fertilization in T. aman rice.

Table 2. Effects of S, Mg and Zn on yield components of T. aman rice Binadhan-7

Treatments	Plant height (cm)	Tillers hill^{-1} (no.)	Panicle length (cm)	Grains panicle^{-1} (no.)	1000-seed weight (g)
T_1 : N_{80} P_{15} K_{40} (Control)	72.7d	8.9d	19.4e	66.3e	21.3c
T_2 : S_{10}	75.8bcd	10.0bc	20.6bcd	80.4bcd	22.3ab
T_3 : Mg_{15}	75.2bcd	9.8bc	20.4cd	78.0cd	22.1bc
T_4 : Zn_2	74.6cd	9.6cd	19. 7de	76.0d	21.9bc
T_5 : S_{10} + Mg_{15}	78.3ab	10.5ab	21.4ab	84.8abc	22.6ab
T_6 : S_{10} + Zn_2	76.9bc	10.3ab	20. 7bc	86.4ab	22.4ab
T_7 : Mg_{15} + Zn_2	75.9bcd	10.1bc	20.6bcd	81.9bcd	22.5ab
T_8 : S_{10} + Mg_{15} + Zn_2	81.8a	11.0a	21.7a	90.0 a	22.9a
CV (%)	3.5	4.8	2.5	5.4	2.0
SE (±)	1.2	0.2	0.3	2.5	0.3

SE = standard error

Grain and straw yield of T. aman rice

Grain yield of T. aman rice responded significantly due to the application of different treatment combinations S, Mg and Zn (Table 3). All the treatment combinations gave significantly higher grain yield over the control. The grain yield varied from 3.13 to 5.52 t ha^{-1}. The highest grain yield of 5.52 t ha^{-1} was recorded with the application of S, Mg and Zn together (T_8) which gave 43.2% yield increment over the control. The second highest grain yield of 5.15 t ha^{-1} was observed in the T_5 treatment comprising all S & Mg containing treatment and it was statistically identical with the treatment T_8. In producing grain yield, the treatment combination may be ranked in order of $T_8 > T_5 > T_6 > T_2 > T_7 > T_3 > T_4 > T_1$. In case of individual effect of S, Mg and Zn, may be ranked in order of S>Mg>Zn. The increase in grain yield due to application of S (Jawahar and Vaiyapuri, 2010), Mg (Choudhury and Khanif, 2001) and Zn (Muthukumararaja and Sriramachandrasekharan, 2012) fertilizer is an agreement with present findings.

Straw yield of T. aman rice, Binadhan-7 was also significantly influenced with the different treatment combinations of S, Mg and Zn (Table 3). The straw yield of T. aman rice varied from 4.7 to 6.8 t ha^{-1}. The highest straw yield (6.8 t ha^{-1}) was recorded with treatment T_8, which was identical with the treatments T_2. Similar findings were reported by many workers (Jawahar and Vaiyapuri, 2010; Choudhury and Khanif, 2001; Muthukumararaja and Sriramachandrasekharan, 2012).

Table 3. Effects of S, Mg and Zn on grain and straw yield of T. aman rice

Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	% increase grain yield
T_1 : N_{80} P_{15} K_{40} (Control)	3.13d	4.70d	-
T_2 : S_{10}	4.62bc	6.30ab	32.2
T_3 : Mg_{15}	4.06c	5.75bc	22.9
T_4 : Zn_2	3.91cd	5.61c	19.9
T_5 : S_{10} + Mg_{15}	5.15ab	5.98bc	39.2
T_6 : S_{10} + Zn_2	4.66bc	5.86bc	32.8
T_7 : Mg_{15} + Zn_2	4.29c	5.83bc	26.9
T_8 : S_{10} + Mg_{15} + Zn_2	5.52a	6.80a	43.2
CV (%)	10.1%	6.07	-
SE (±)	0.26	0.21	-

SE = standard error

Nutrient content and uptake by T. aman rice grain and straw

Sulphur

The highest S (0.142%) content in rice grain was recorded with the treatment followed by the treatment T_5 (0.139%) T_8. The lowest S (0.095%) content was noted in T_1 treatment (Table 4). Similar results were observed in case of rice straw. Hossain *et al.* (1989) reported that S content in rice straw increased considerably due to the addition of S applied as gypsum. Similar results were also reported by Hoque and Eaqub (1984).

The highest S uptake (7.84 kg ha^{-1}) was obtained by rice grain in the treatment T_8 and the lowest (2.99 kg ha^{-1}) was found in the control. The total S uptake by T. aman rice varied from 7.5 to 19.7 kg ha^{-1} (Table 6). Islam *et al.* (1997) and Xie and Mamaril (1992) reported that application of S significantly increased S uptake by rice. Yoshida and Chowdhury (1979) and Islam *et al.* (1990) reported that application of sulphur increased the S content in straw of BR2 rice. The present findings are well accordance with those earlier findings.

Magnesium

Magnesium content in rice grain varied from 0.122 to 0.229% due to application of Mg whereas Mg content in rice straw varied from 0.209% in treatment T_1 (control) to 0.376% in treatment T_8 (Table 4). The highest Mg content was noted with the treatment T_8 both in grain and straw. The Mg uptake by grain varied from 5.73 to 15.56 kg ha^{-1} and by straw varied from 9.77 to 18.93 kg ha^{-1}. The total Mg uptake by rice varied from 15.5 to 34.5 kg ha^{-1} (Table 6). However, the Mg content of all the treatments was higher than that of the control. The increase in Mg uptake due to Mg fertilization is an agreement with the findings of Choudhury and Khanif (2011) and Fageria *et al.* (1991).

Zinc

The Zn content in rice grain varied from 27.0 µg g^{-1} in T_1 (control) to 30.9 µg g^{-1} in T_8 treatment and Zn content in rice straw varied from 51.67 µg g^{-1} in T_1 (control) to 84.23 µg g^{-1} in the treatment T_8 (Table 4). Hossain *et al.* (1989) reported that Zn content in both grain and straw increased considerably due to Zn addition to soil in T. aman rice. Maharana *et al.* (1993) reported that Zn concentration of rice grain and straw increased with applied $ZnSO_4$ and the concentration was more in straw than in grain. The Zn uptake by grain of T. aman rice varied from 0.085 to 0.17 kg ha^{-1} and by straw varied from 0.245 to 0.572 kg ha^{-1} (Table 5). The total Zn uptake by grain plus straw ranged from 0.33 to 0.74 kg ha^{-1} (Table 6). Zn uptake by the crop was closely associated with the yield of grain and straw.

Table 4. Effect of S, Mg and Zn fertilization on S, Mg and Zn content in grain and straw of T. aman rice

Treatments	Nutrient contents					
	Grain			Straw		
	S (%)	Mg (%)	Zn (μg g^{-1})	S (%)	Mg (%)	Zn (μg g^{-1})
T_1 : N_{80} P_{15} K_{40} (Control)	0.095f	0.122c	27.00d	0.098d	0.209bc	51.67b
T_2 : S_{10}	0.135c	0.137c	27.25cd	0.165abc	0.214bc	52.49b
T_3 : Mg_{15}	0.11e	0.200ab	27.27cd	0.12cd	0.250b	53.60b
T_4 : Zn_2	0.114d	0.128c	30.55ab	0.118bcd	0.162c	81.22a
T_5 : S_{10} + Mg_{15}	0.139b	0.209ab	27.44bcd	0.166ab	0.232bc	52.77b
T_6 : S_{10} + Zn_2	0.138b	0.168bc	30.43abc	0.168ab	0.21bc	81.43a
T_7 : Mg_{15} + Zn_2	0.119d	0.204ab	30.84a	0.126a-d	0.237bc	79.84a
T_8 : S_{10} + Mg_{15} + Zn_2	0.142a	0.229a	30.90a	0.175a	0.376a	84.23a
CV (%)	4.1	18.8	6.3	12.0	10.5	6.8
SE (±)	0.003	0.012	1.056	0.018	0.028	2.616

SE = standard error

Table 5. Effect of S, Mg and Zn fertilization on S, Mg and Zn uptake in grain and straw of T. aman rice

Treatments	Uptake (kg ha^{-1})					
	Grain			Straw		
	S	Mg	Zn	S	Mg	Zn
T_1 : N_{80} P_{15} K_{40} Control)	2.99d	5.73e	0.085g	4.47d	9.77cd	0.245d
T_2 : S_{10}	6.23b	8.62cde	0.126d	10.45ab	13.52bc	0.331c
T_3 : Mg_{15}	4.48c	11.39bc	0.111f	6.33d	14.36b	0.308c
T_4 : Zn_2	4.62c	7.27de	0.119e	6.65cd	8.91d	0.456b
T_5 : S_{10} + Mg_{15}	7.16ab	12.47b	0.132c	9.91abc	13.86bc	0.315c
T_6 : S_{10} + Zn_2	6.43b	9.75bcd	0.142b	9.72abc	12.12bcd	0.477b
T_7 : Mg_{15} + Zn_2	5.09c	11.89b	0.133c	7.35bcd	13.81bc	0.466b
T_8 : S_{10} + Mg_{15} + Zn_2	7.84a	15.56a	0.170a	11.82a	18. 93a	0.572a
CV (%)	10.7	16.8	12.1	13.1	16.9	9.1
SE (±)	0.35	1.003	0.009	1.113	1.37	0.021

SE = standard error

Table 6. Total S, Mg and Zn uptake (grain + straw) of T aman rice (Binadhan-7)

Treatments	Total uptake (grain + straw) (kg ha^{-1})		
	S	Mg	Zn
T_1 : N_{80} P_{15} K_{40} (Control)	7.5	15.5	0.33
T_2 : S_{10}	16.7	22.1	0.46
T_3 : Mg_{15}	10.8	25.8	0.42
T_4 : Zn_2	11.3	16.2	0.58
T_5 : S_{10} + Mg_{15}	17.1	26.3	0.46
T_6 : S_{10} + Zn_2	16.2	21.9	0.62
T_7 : Mg_{15} + Zn_2	12.4	25.7	0.60
T_8 : S_{10} + Mg_{15} + Zn_2	19.7	34.5	0.74

Correlation matrix

To examine the interrelationship among the yield and yield components, correlation statistics was done (Table 7). The values of correlation coefficient indicated that grain yield was dependent on panicle length (r = 0.61**, p<0.01), grains $panicle^{-1}$ (r = 0.51*, p<0.05) and 1000-grain weight (r = 0.59**, p<0.01) and there was no correlation with plant height, tillers $hill^{-1}$. Grain yield was also significantly correlated with straw yield (r = 0.60**, p<0.01).

Table 7. Correlation matrix among the yield components of T. aman rice as affected by different treatments (n = 24)

Treatments	Plant height	Tillers $hill^{-1}$	Panicle length	Grains $panicle^{-1}$	1000-grain weight	Grain yield	Straw yield
Plant height	1.00						
Tillers $hill^{-1}$	0.66**	1.00					
Panicle length	0.43*	0.58**	1.00				
Grains $panicle^{-1}$	0.64**	0.54**	0.67**	1.00			
1000-grain weight	0.63**	0.65**	0.72**	0.53**	1.00		
Grain yield	0.40^{NS}	0.35^{NS}	0.61**	0.51*	0.59**	1.00	
Straw yield	0.65**	0.62**	0.65**	0.63**	0.53**	0.60**	1.00

* = significant at 5% level of probability, ** = significant at 1% level of probability, NS = non-significant.

Conclussion

From the results of the study it can be suggested that application of S, Mg and Zn at the rate of 10, 15 and 2 kg ha^{-1}, respectively along with recommended dose of N, P and K is necessary for obtaining higher grain yield of T. aman rice with increased nutrients content.

Reference

BARC. 2005. Fertilizer Recommendation Guide. Bangladesh Agricultural Research Council, Soils Pub., 45, Dhaka.

BBS. 2011. Year Book of Agricultural Statistics of Bangladesh. Bangladesh Bureau of Statistics. Ministry of Planning, Govt. of the People's Republic of Bangladesh, Dhaka, p. 47.

Chande1, R. S., Sudhakar P. C. and Kaiyan Singh. 2003. Response of sulphur in rice – a review. Agric. Rev., 24(3): 167-174.

Choudhury, T. M. A. and Khanif, Y. M. 2001. Evaluation of effects of nitrogen and magnesium fertilization on rice yield and fertilizer nitrogen efficiency using ^{15}N tracer technique. J. of Plant Nutr., 24(6): 855-871.

Choudhury, T. M. A. and Khanif, Y. M. 2011. Effects of nitrogen, cupper and magnesium fertilization on nutrition of some macro and micronutrients of rice crop in Malaysia. Bangladesh Res. Pub. J. 5(3): 201-206.

Fageria, N. K. and Souza, C. M. R. D. 1991. Upland rice, common bean and cowpea response to magnesium application on an Oxisol. Commun. Soil Sci. Plant Anal., 22 (17&18): 1805-1816.

Fageria, N.K., Dos Santos, A. B. and Cobucci, T. 2011. Zinc nutrition of lowland rice. Comm. Soil Sci. Plant Anal., 42: 1719-1727.

FAO. 2012. Yearbook of Production. Food and Agricultural Organization. FAO, Statistics Division. p. 222.

Gee, G. W. and Bauder, J. W. 1986. Particle-size analysis. In Methods of Soil Analysis part 1. A. Klute (edi.), Soil Sci. Soc. of Am. Book Series 5, Madison, Wisconsin, USA, pp. 383-411.

Gomez, K. A and Gomez, A. A. 1984. Statistical Procedures for Agricultural Research. Int. Rice Res. Inst., John Wiley & Sons, N.Y.

Hoque, M. S. and Eaqub, M. 1984. Study on zinc and sulphur deficiency in Bangladesh soils Ann. Rep. FAO Project (1983-’84).

Hossain, S. M. A., Sattar, M., Ahmed, J. U. and Islam, J. U. 1989. Response of rice to different levels of Zn fertilizer. Bangladesh J. Agric. Sci., 16(1): 125-127.

Hunter, H. 1984. Soil Fertility Analytical Service in Bangladesh. Consultancy Report, BARC, Dhaka.

Islam, M. R., Hoque, M. S. and Bhuiyan, Z. H. 1990. Effect of nitrogen and sulphur fertilizer on yield response and nitrogen and sulphur composition of rice. Bangladesh J. Aric. Sci., 17(2): 299-302.

Jahiruddin, M. and Rigpma, J. 2004. National strategy and plan for use of soil nutrient balance in Bangladesh. Final report of short term assignment. SFFP-DANIDA.

Jahiruddin, M., Ali, M. S., Hossain, M. A., Ahmed, M. U. and Hoque, M. M. 1995. Effect of boron on grain set, yield and some other parameter of wheat cultivars. Bangladesh J. Agric. Sci., 22: 179-184.

Jawahar, S. and Vaiyapuri, V. 2010. Effect of sulphur and silicon fertilization on growth and yield of rice. Int. J. Curr. Res., 9: 36-38.

Khurana, M. P. S., Sadana, U. S. and Bijaysingh. 2008. Sulfur nutrition of crops in the Indo Gangetic plains of South Asia. In Sulfur: A missing link between soils, crops and nutrition. Agronomy monograph no. 50. pp. 11-24.

Maharana, D. P., Sarengi, S. K., Singh, R. N. B., Ali, M. H. and Ali, M. H. 1993. Response of rice to application of zinc sulphate in different broad soil groups of Orissa. In Proc. Workshop on micronutrients. IBFEP, HFC, Bhubaneswar, Orisaa, India. 22-23 January, 1993, pp. 228-238.

Muthukumararaja, T. M. and M. V. Sriramachandrasekharan. 2012. Effect of zinc on yield, zinc nutrition and zinc use efficiency of lowland rice. J. Agril. Tech., 8(2): 551-561.

Nelson, D. W. and Sommers, L. E. 1982. Total carbon, organic carbon and organic matter. In: Page, A.L. (Ed.), Methods of Soil Analysis Part 2. Agron. Monogr. No. 9. 2nd ed. ASA an SSSA, Madison, WI, pp. 539-580.

Olsen, S. R., Cole, C. V., Watanable, F. S. and Dean, L. A. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. U. S. Dept. Agric. Cire., p. 929.

Page, A. L., Miller, R. H. and Keeney D. R. 1982. Methods of Soil Analysis, Part 2, Second Ed., Amer. Soc. Agron., Madi., Wis., USA.

Rahman, M. T., Jahiruddin, M., Humauan, M. R., Alam, M. J. and Khan A. A. 2008. Effect of sulphur and zinc on growth, yield and nutrient uptake of boro rice (cv. BRRI dhan29). J. Soil. Nature, 2(3):10-15.

Russel, D. F. 1986. MSTAT-C Package Programme. Crop and Soil Sci. Dept., Michigan State Univ. USA.

Sakai, H. 1980. Some analytical results of sulfur deficient plants, soil and water, pp. 35-39. In Proceedings of the workshop on sulfur nutrition in rice. Publication no. 41. Bangladesh Rice Research Institute, Dhaka, Bangladesh.

Samy, J., Zahari, A. B. and Lee, C. S. 1992. Nutrient requirement of rice after two decades of double cropping in Malaysia. In Proceedings of International Symposium on Paddy Soils. Chinese Academy of Sciences: Beijing, China, pp. 283-289.

Xie, L. S. and Mamaril, C. P. 1992. Oxidation and management of elemental sulphur in lowland rice soils. Proc. Int. Symp. Paddy Soils, Nanjing, China. 15-19 September, pp. 205-206.

Yoshida, S. and Chowdhury, M. R. 1979. Sulphur nutrition of rice Soil Sci. Pl. Nutri., 25(1): 121-134.

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EFFECT OF TRICHODERMA AND PROVAX ON COLLAR ROT AND STEMPHYLIUM BLIGHT OF LENTIL

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Abstract

The experiment was conducted at Bangladesh Institute of Nuclear Agriculture (BINA) farm, Mymensingh and BINA sub-station farms, Magura and Ishurdi to control collar rot caused by *Fusarium solani* and *Sclerotium rolfsii* and stemphylium blight caused by *Stemphylium sarciniformis* and *Stemphylium botryosum* of lentil with *Trichoderma harzianum* (50 g per^{-} m^2 soil) and Provax (0.3% of seed weight). *T. harzianum* showed better performance in seed germination (90.9-93.8%) against collar rot while in filled pods plant^{-1} (47.9-137.6) and yield per m^2 (141.0 g) against collar rot and stemphylium blight. On the contrary, *T. harzianum* resulted the lowest seedling mortality (collar rot = 0.48%, stemphylium blight = 12.3-14.7%) and unfilled pods plant^{-1} (2.0-6.6) over control against collar rot and stemphylium blight. Provax exhibited more or less similar performance to *T. harzianum* in all the mentioned parameters.

Keywords: *T. harzianum*, Provax, Collar rot, Stemphylium blight, Lentil

Introduction

Lentil (*Lens culinaris esculenta*) has a great impact in the world agriculture due to its high protein content and special capacity for fixing atmospheric nitrogen. In addition, the food value of lentil plays an important role in cropping system for its ability to fix nitrogen (101 kg ha^{-1} annum^{-1}) and thereby enriches the soil status (Anonymous, 1984). It ranked second in position in legume crops in terms of production area and yield.

Various causes are associated with low yield of pulses in the country. Diseases are major constrains to lentil production all over the world (Bayaa and Erskime, 1998). It suffers from 17 diseases (Baker and Rashid, 2007). Among them stemphylium blight is the most devastating and wide spread disease in Bangladesh as well as in the other countries like India, Pakistan, Iran, Syria and Canada (Hartman, 2002; Hossain, 2003). In Bangladesh, Stemphylium blight and collar rot may result 88% and 44.4% yield loss of lentil, respectively (Jalaluddin, 2005).

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T. harzianium has an antagonistic character against many soil borne fungi such as *Rhizoctonia solani, Sclerotium rolfsii, Fusarium solani* etc. (Strashnow *et al.*, 1985). Integration between biocontrol agents and plant pathogens has been studied extensively and application of biocontrol agents to protect some commercially important crops is the most promising management tactic. In Bangladesh management of collar rot and stemphylium blight is highly dependent on chemical fungicides. However, non judicious and continuance use of chemicals over a long period of time is known to have adverse impact on environment (Ndoumbe and Sache, 2003), whereas, using antagonistic microorganisms is an effective alternative measure for plant disease management. Keeping this in view the present study was carried out to compare the efficacy of seed treatment with *T. harzianum* and Provax for controlling collar rot and stemphylium blight of lentil.

Materials and Methods

The experiment was conducted at Bangladesh Institute of Nuclear Agriculture farm, Mymensingh and BINA sub-station farms, Magura and Ishurdi following a randomized complete block design with three replications during October 2011 to April 2012. Binamasur-2 was used as susceptible variety to collar rot and stemphylium blight. The treatments were (i) Biocontrol agent (*T. harzianum*) (ii) Fungicide (provax) and (iii) Control. *T. harzianum* grown on pulse bran was mixed thoroughly with the soil @ 50 g per m^2. The seeds were treated with provax @ 0.3% of seed weight. Plants watered with sterilized water served as control. The soil of the experimental plots was well pulverized by six ploughing followed by laddering. The weeds and stubbles were removed from the field and the field was leveled properly before sowing. Fertilizers were applied according to BARI Hand Book, 2005 @ 45 kg Urea, 85 kg TSP and 35 kg MP ha^{-1}. One thousand eight seeds (120 seeds per line) were sown in 4 m × 3 m unit plot having 9 lines, on 17, 20 and 23 November at Mgura, Ishurdi and Mymensingh, respectively. The crop was harvested at pod maturity stage. Harvesting was done on 16, 19 and 20 March, 2012 at Magura, Ishurdi and Mymensingh, respectively. Data on germination and seedling mortality, yield and yield contributing characters of lentil were recorded against both diseases.

Results and Discussion

T. harzianum (50 g per m^{-2}) and provax (0.3% of seed weight) were at par with each other in respect to seed germination and seedling mortality at Magura and Mymensingh against collar rot of lentil (Table 1). At Ishurdi, *T. harzianum* performed better than provax in increasing seed germination and decreasing seedling mortality. However, the control treatment always showed the lowest seed germination and highest seedling mortality at all the locations.

Significantly least seed germination and seedling mortality against stemphylium blight were recorded in *T. harzianum* treated soil while the highest was observed in untreated control (Table 2). Seeds treated with provax occupied the intermediate position at all the locations.

The present findings correlate with the findings obtained by Baker (1991) and Rahman *et al* (2006) who reported that soil borne pathogens were reduced, legume seed germination were increased (up to 62%) and seed mortality were decreased considerably with the application of *T. harzianum* in soil. Similar results were also reported by Begum *et al.* (1999), Monaco *et al* (1991) and Sultana (2001). Further, Begum (2008) found that seed treatment with cell suspension and talcum powder based formulation (in soil) of *T. harzianum* and *T. viride* increased seed germination, shoot length, root length and seedling vigour. Seedling emergence and health of seedlings improved when tomato seeds were treated with *T. harzianum* (Rahman *et al.*, 2001; Begum and Meah, 2007).

Soil treatment with *T. harzianum* responded better in increasing filled pods plant^{-1} and pod yield plant^{-1} and decreasing unfilled pods plant^{-1} than seed treatment with provax at Magura and Ishurdi while at Mymensingh *T. harzianum* and provax performed almost similar results on yield parameters (Table 3). Both seed (provax) and soil (*T. harzianum*) treatment always showed highest yield contributing characters over control. The distinct and profound antagonistic effect of *T. harzianum* over *S. rolfsii* and *Stemphylium botryosum* was reported by Begum *et al.* (1999) and Hossain (2003). There are several reports indicating the use of chemicals as seed and soil treatment against soil borne plant pathogens such as *Fusarium, Sclerotium, Rhizoctonia* species (Sharma and Kumar, 2000, Begum, 2008). *Trichoderma* spp. improved plant growth in terms of shoot length, root length and yield parameters of pulses against collar rot and stemphylium blight (Hartman *et al.,* 2002; Sultana and Hossain, 1999; Jalaluddin, 2005; Kashem, 2005).

Performance of soil treatment with *T. harzianum* and seed treatment with provax were statistically similar in plants stand and yield m^{-2} but higher than untreated control (Fig. 1 and Fig. 2). However, when *T. harzianum* applied in soil showed better performance in plants stand (61.7-82%) and yield (64.3-141 g m^{-2}) than seeds treated with provax (plants stand = 60.3-81%, and yield = 62.3-139.7 g m^{-2}). The untreated control showed the lowest plants stand (47.7%-70.7%) and yield (46.7-124.7 g m^{-2}) in all the locations. The control treatment showed much higher susceptibility towards both the pathogens. *T. harzianum* had marked effect on the yield of legume crops (Prashad *et al.*, 2002; Faruk *et al.,* 2002). Soil inoculation with *T. harzianum* and *T. viride* were responsible for higher yield of pulses and vegetables than fungicides (Krishnamoorthy and Bhaskaran, 1990; Mukhopadhyay, 1989; Prashad *et al.*, 2002).

Conclusion

Provax is a chemical fungicide. It has some adverse effect on environment. On the other hand *T. harzianum* is soil and environment friendly. Moreover, provax is costly than *T. harzianum. T. harzianum* has similar and sometimes more disease controlling and yield contributing character than provax. So, farmers can easily use *T. harzianum* as soil treatment at low cost for controlling collar rot and stemphylium blight of lentil.

Table 1. Effect of *Trichoderma harzianum* and provax on seed germination and seedling mortality against collar rot of lentil

Observations	Treatments	Locations		
		Mugura	Ishurdi	Mymensingh
Germination (%)	*Trichoderma harzianum*	92.3	93.8	90.9
	Provax (0.3% of seed weight)	92.5	91.0	90.7
	Control (untreated)	87.9	84.0	88.2
	LSD (p>0.05)	**2.58**	**1.20**	**2.10**
Seedling mortality (%)	*Trichoderma harzianum*	0.48	0.48	0.48
	Provax (0.3% of seed weight)	0.51	0.59	0.59
	Control (untreated)	0.70	0.95	1.48
	LSD (p>0.05)	**0.14**	**0.02**	**0.14**

Table 2. Effect of *Trichoderma harzianum* and provax on seed germination and seedling mortality against stemphylium blight of lentil

Observations	Treatments	Locations		
		Mugura	Ishurdi	Mymensingh
Germination (%)	*Trichoderma harzianum*	60.0	5.0	60.0
	Provax (0.3% of seed weight)	73.3	20.0	70.0
	Control (untreated)	90.0	45.0	90.0
	LSD (p>0.05)	**1.16**	**1.09**	**6.4**
Seedling mortality (%)	*Trichoderma harzianum*	3.0	0.0	3.0
	Provax (0.3% of seed weight)	5.0	3.0	5.0
	Control (untreated)	7.0	5.0	7.0
	LSD (p>0.05)	**0.5**	**0.5**	**0.6**

Table 3. Effect of *Trichoderma harzianum* and provax on yield parameters of lentil

Observations	Treatments	Locations		
		Mugura	Ishurdi	Mymensingh
Filled pods plant^{-1}	*Trichoderma harzianum*	137.6	128.3	47.9
	Provax (0.3% of seed weight)	133.2	114.3	48.2
	Control (untreated)	111.4	94.9	36.9
	LSD (p>0.05)	**1.46**	**82.3**	**1.7**
Unfilled pods plant^{-1}	*Trichoderma harzianum*	2.46	6.60	2.00
	Provax (0.3% of seed weight)	4.20	9.60	2.26
	Control (untreated)	6.86	12.94	2.54
	LSD (p>0.05)	**0.60**	**0.12**	**0.20**
Pod yield plant^{-1} (g)	*Trichoderma harzianum*	3.26	3.06	1.26
	Provax (0.3% of seed weight)	3.06	2.54	1.34
	Control (untreated)	2.34	1.74	0.74
	LSD (p>0.05)	**0.41**	**0.15**	**0.07**

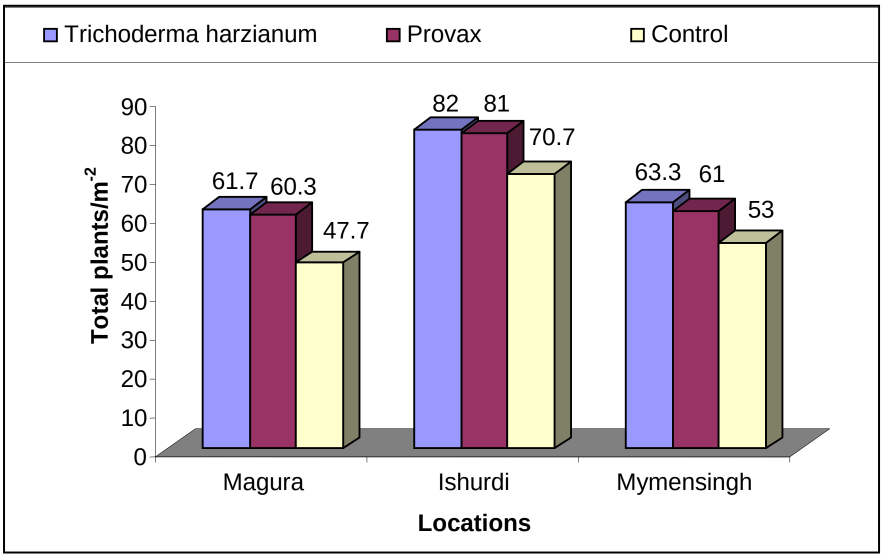

Fig. 1. Effect of *Trichoderma harzianum* and provax on plants stand per meter square

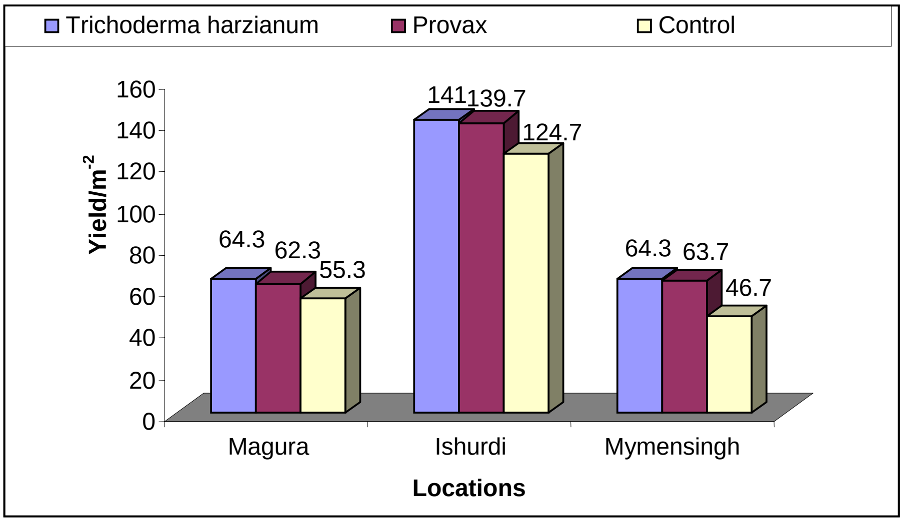

Fig. 2. Effect of *Trichoderma harzianum* and provax on yield gram per meter square

References

Anonymous, 1984. A guide book on production of pulses in Bangladesh. FAO/UNDP Project strengthening the agriculture extension service. Khamarbari, Farmgate, Dhaka, Bangladesh.

Baker, M. A. and Rashid, M. B. 2007. Integrated management of Stemphylium blight of lentil. Bangladesh J. Agrils. Res., 25(4): 9-14.

Bayaa, B. and Erskine, W. 1998. Diseases of lentil. The Pathology of Food and Pasture legumes. Edited by Allen, D. J. and Lenne, J. M. p. 473.

Begum, H. A. 2008. Studies of integrated management for tomato wilt complex. Ph. D. thesis. Department of Plant Pathology. Bangladesh Agricultural University, Mymensingh. p. 239.

Begum, H. A. and Meah, M. B. 2007. Biocontrol of *Fusarium oxysporum* f. sp. *lycopersici*. Mol. Biol. Biotechnol. J. 5(1&2): 28-31.

Begum, M. M., Rahman, M. A. and Hossain, I. 1999. Antagonistic effect of *Trichoderma harzianum* on *Sclerotium rolfsii* in food legumes. J. Bio. Sci., 7: 81-88.

Faruk, M. I., Bari, M. A. and M. A. Rahman. 2002. Efficacy of *Trichodrma* as bio-control agent against foot and root rot of Bush bean. Bangladesh J. Agril. Res., 27(4): 657-662.

Hartman, J., Neshmith, W., Vincelli, P. and Hershman, D. 2002. Biological control products available for disease management. Kentucky Pest News. United Kingdom. 970: 4-6.

Hossain, L. 2003. Use of BAU-Biofungicide to control seed borne diseases of vegetables and pulses. Bangladesh Agricultural University, Mymensingh, p. 18.

Jalaluddin, M. 2005. Effect of seed treatment on disease incidence of lentil. MS. Thesis, Department of Plant Pathology, BAU, Mymensingh, pp. 30-35.

Kashem, A. 2005. *Trichoderma* in controlling foot and root rot and collar rot of lentil. Ph. D, thesis, Department of Plant Pathology, Bangladesh Agricultural University, Mymensingh. Bangladesh, pp. 182-185.

Krishnamoorthy, A. S. and Bhaskaran, R. 1990. Biological control of damping off seedlings of tomato caused by *Pythium indicum*. Balakrishnan. J. Biological Control. 4(1): 52-54.

Monaco, C; *Perello*, Ali, H. E. and Pasquare, A. O. 1991. *Trichoderma* spp. a biocontrol agent of *Fusarium* spp. and *Sclerotium rolfsii* and seed treatment. Advances in Hort. Sci., 5(3): 92-95.

Mukhopadhyay, A. N. 1989. National seminar and workshop of AICRP on biological control. Lucknow. pp. 23-25.

Ndoumbdè-Nkeng M and Sache I, 2003. Lutte contre la pourriture brune des cabosses du cacaoyer au Cameroun. Phytoma. *la Défense des Végétaux* 562: 10-12.

Prasad, R. D., Rangeshwaran, R. Anuroop, C. P. and H. J. Rashmi, 2002. Biological control of wilt and root rot of cheickpea under field conditions. Annals Plant Protec. Sci., 10(1): 72-75.

Rahman, M. M. 2006. Potentiality of BAU-Biofungicide for controlling seedling diseases of papaya, watermelon and melon. M.S. Thesis, Department of Agronomy, Bangladesh Agricultural University, Mymensingh, Bangladesh, p. 74.

Rahman, M. R., Faruk, M. I., Rahman, M. L., Begum, F. and Bari, M. A. 2001. Suppression of tomato seedling disease by *Trichoderma harzianum* isolates. + Bangladesh J. Pl. Pathol., 17(1-2): 1-4.

Sharma, J. P. and Kumar, S. 2000. Management of Ralstonia wilt through soil disinfectant, mulch, lime and cakes in tomato (*Lycopersicon esculentum*). Indian J. Agric. Sci., 70(1): 17-19.

Starshnow, Y., Elad, Y., Sivan, A., Rudich, Y. and Chet, I. 1985. Control of *Rhizoctonia solani* fruit rot of tomatoes by *Trichoderma harzianum*. Crop Protec., 4(3): 359-364.

Sultana N. and I. Hossain. 1999. Biological control of foot and root rot of lentil with *Trichoderma harzianum.* Bangladesh J. Seed Sci. & Technol., 3 (1&2): 107-111.

Sultana, N. 2001. Biological control of foot and root rot of lentil with *Trichoderma harzianum*. M.S. Thesis. Department of Plant Pathology. Bangladesh Agric. University, Mymensingh, Bangladesh.

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INCREASING CROPPING INTENSITY AND PROFITABILITY IN DRY BARIND AREA OF BANGLADESH, UTILIZING PROFILE SOIL MOISTURE AND SUPPLEMENTAL IRRIGATION

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Abstract

Under the current scarcity of land and the continued growth of population, there is no alternative but to continue intensifying agricultural production in Bangladesh. This urges for vertical expansion of agriculture. A large part of Barind area, north-western part of Bangladesh, suffers from dryness due to low and erratic rainfall, remains fallow during winter and dry season period. This study attempted to increase cropping intensity through conserving and utilizing profile soil moisture and minimal supplemental irrigation application. Rice-Fallow-Fallow, Rice-Chickpea-Sesame, Rice-Chickpea-Mungbean cropping patterns with different irrigation and mulching practices for dry-season crops were investigated, and economic analyses were performed to find out the most economic pattern couple with minimal irrigation water application. From the results of field experiments and economic analyses, Rice-Chickpea-Mungbean pattern identified the best as with 'Binadhan-7' for transplant Aman rice, 'Binasola-4' for chickpea, and 'Binamoog-5' for mungbean. A net profit of BDT 1,38,850.00 per hectare equivalent to US$ 1,734 can be obtained from this practice applying 6 cm water in dry-season crops chickpea and mungbean, which is BDT 94,468.00 equivalent to US$ 1,181 per hectare higher than the existing local pattern. This practice, if implemented over the dry area, can improve the livelihood of the farmers and food security of the country.

Keyword: Barind tract, Bangladesh, Cropping intensity, Net profit, Moisture conservation, Mulching, Rabi season, Kharif-1 season

Introduction

The north-western part of Bangladesh, the Barind Tract area, receives a low annual rainfall than that of the other regions of the country. Long-term (1976-2008) average annual rainfall of this area (Rajshahi district) is about 1500 mm, which, for national average is about 2300 mm. Approximately 83% of the annual rainfall occurs during the months of May–September which is noted as monsoon season. Owing to the absence of surface water resource, ground water is the primary source of water for dry-season cropping.

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After the establishment of ‘Barind Integrated Area Development Project’ (presently ‘Barind Multipurpose Development Authority’), a large number of deep tubewells have been installed sequentially to bring the seasonal fallow land under Boro rice cultivation. But about 30 % of the barind area remains without irrigation facility (non-DTW area). The area having tubewell irrigation facility is being green during crop season at the cost of deterioration of the groundwater reserve (Sarkar *et al.*, 2010; Ali *et al.*, 2012). This happens due to insufficient recharge, which is caused by low rainfall and its erratic distribution throughout the year.

In non-DTW area, the fate of crop yield and cropping intensity depends on the climate, specially natural rainfall. At present days, the impact between socio-economic development, water shortage and environmental degradation become increasingly critical. Future climate change and global warming can cause additional uncertainty in water resources and crop production in this area. Research results showed that increase in maximum temperature 10% can increase the crop evapotranspiration demand by 7-9% (Ali and Adham, 2007).

Past research efforts toward growing crop in the area in dry season suggest that low water demanding crops can be grown with proper soil moisture conservation practices and proper crop planning using probability analysis of weather parameters, specially rainfall (Hassan *et al.*, 2003; Ali *et al.*, 2005a; Ali *et al.*, 2005b; Ali and Talukder, 2008). Research results also evident it has been observed that in dry-land cereals (except rice), pulses and oilseeds, one irrigation at early stage can increase the yield up to 40% compared to non-irrigated one (Sarkar *et al.*, 2002; Sarkar *et al.*, 2000; Hassan *et al.*, 2000; Ali *et al.*, 2007).

The objective of this research work was to develop technique(s) to grow low water-demanding crop(s) in dry season with appropriate soil moisture conservation practice and supplemental irrigation, if necessary.

Materials and Methods

The following activities were carried out to reach the foresaid objective:

- Investigated three (3) different cropping patterns (adding crop in dry season), adopting different crops to find out the best pattern in terms of yield and irrigation water need
- Adopted different soil-moisture conservation practices (for dry season crops) to select the best practice
- Evaluated net profit for each pattern to find out the best profitable one

Description of the study area

Site location

The north-western region of Bangladesh is mainly occupied by Pleistocene deposits (Morgan and McIntire, 1959). It covers the district of Rajshahi, Natore and Bogra. This region is situated between $24^{o}22'$ to $24^{o}51'$ North and $89^{o}18'$ to $89^{o}22'$ East. The present study is, however, based on part of a configuration of three districts (Rajshahi district only, comprising sub-districts called ‘Upazila’). The location map of the studied area is shown in Fig.1.

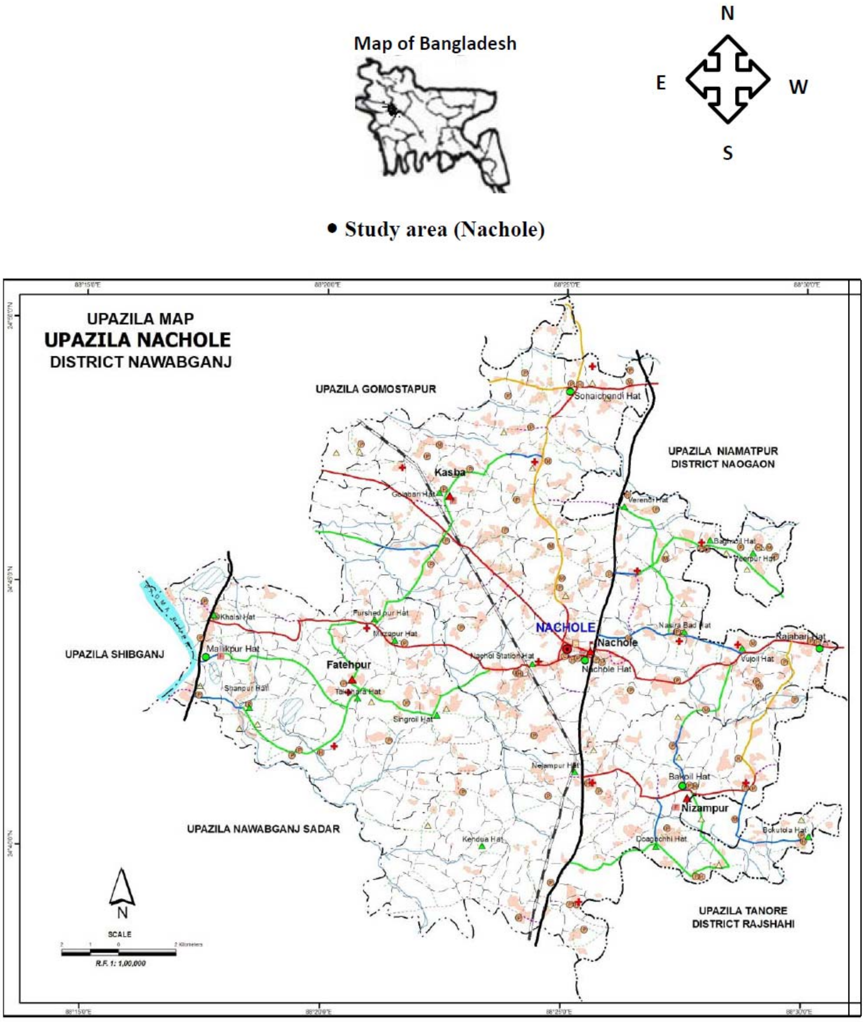

Fig. 1. Location map of the study area

Topography and hydro-geological conditions

The topography of the region is characterized by two distinct land forms: (a) The Barind tract- dissected and undulating, and (b) The floodplains. The elevated Barind tract is characterized by less infiltration due to clayey and semi to impermeable Barind clay with excessive surface runoff. Morpho-stratigraphically, the region is subdivided into three geological units: (1) Barind clay residuum-overlies and developed on Pleistocene alluvium, (2) Holocene Ganges flood-plain alluvium, (3) Active channel deposits of the Ganges and major distributaries (modern alluvium). The lithology types include alluvial sand, alluvial silt, Barind clay residuum, and Marsh clay and peat (Alam *et al.*, 1990). Hydrogeologically, the area covered by semi-impervious clay-silt aquitard of Recent-Pleistocene period (thickness 3.0-47.5 m) is characterized by single to multiple layered (2-4) aquifer system of Plio-Pleistocene age (thickness 5.0-42.5 m) (Jahan *et al.*, 2005).

Rainfall pattern of the area

The annual rainfall at the study site varies from 843 to 2241 mm; approximately 83% of this rainfall occurs during the months of May-September which is noted as monsoon season (Fig. 2). The yearly rainfall fluctuates considerably; having mean, standard deviation and coefficient of variation of 1532 mm, 294 mm, and 19 %, respectively. Rainfed farming is carried out during the rainy seasons and mostly the land is left fallow during the dry seasons.

Existing cropping pattern

During monsoon rainfall, transplant Aman rice is grown in the area. During the rest of the period of the year, the lands remain fallow (i.e., cropping pattern is: T. aan-fallow-fallow).

Experimental details

Cropping patterns

We tried the following cropping patterns in the area:

Pattern	Details
CP_1 (Pattern-1: Control–existing pattern, with existing cultivar)	Rice–Fallow–Fallow
CP_2 (Pattern-2)	Rice–Chickpea–Sesame
CP_3 (Pattern-3)	Rice–Chickpea–Mungbean

In all patterns, transplant Aman (T. aman) rice was grown as rainfed condition (no supplemental irrigation). In pattern-1 (existing pattern), the local cultivar ‘Sumon’ was grown. In other two patterns, a short duration rice variety ‘Binadhan-7’ was used. In chickpea, sesame and mungbean, different irrigation and/or mulching practices were tested. In profitability analysis, the best treatment combination was used.

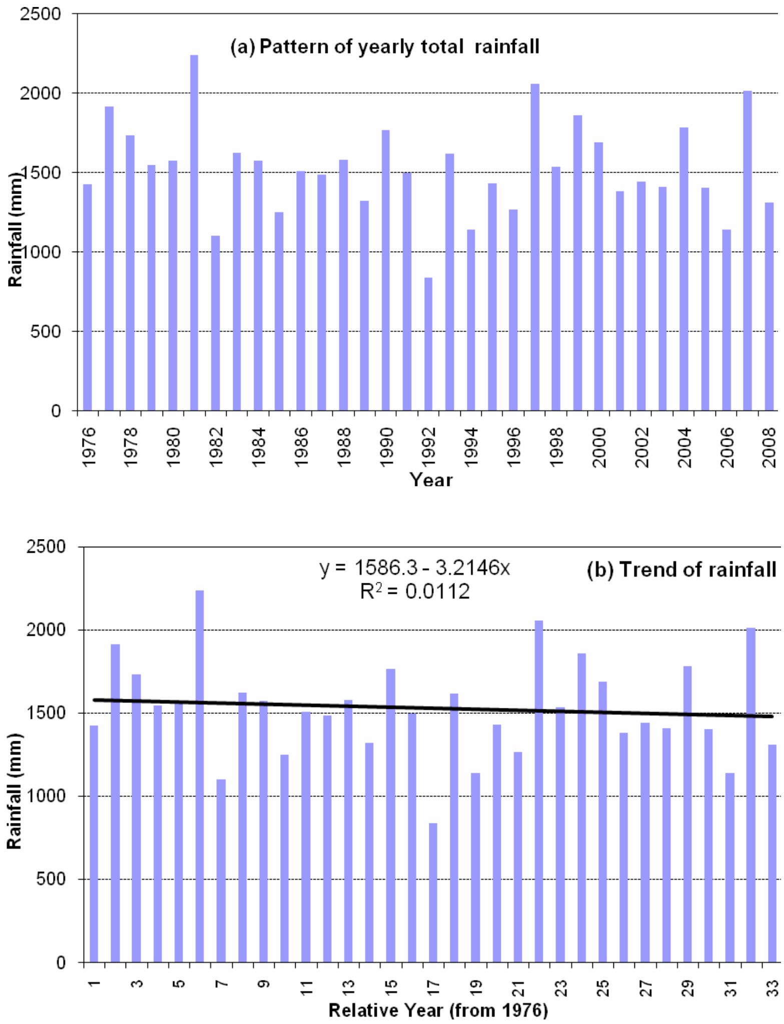

Fig. 2. Long-term rainfall pattern and trend at the study area

Mulching/Irrigation treatments under different crops

Chickpea

After T. aman rice, the same plot and layout were used for the successive crop chickpea of the pattern. Seeds of three chickpea varieties were sown following split-plot design on 22 November 2010 at 5 cm distance within rows of 20 cm apart. The individual and sub-plot sizes were 4 m × 5 m and 2 m × 5 m, respectively, and the treatments were replicated thrice. Recommended fertilizer doses for the varieties were applied. The treatments were as follows:

Main plot treatments: Irrigation and mulch

W_0 = No irrigation + no mulch
W_1 = No irrigation + mulching (straw)
W_2 = Irrigation at vegetative stage + no mulch
W_3 = Irrigation at vegetative stage + mulching (straw)

Sub-plot treatments: Varieties

V_1 = Binasola-4
V_2 = Binasola-5
V_3 = BARI Chola-5

Sesame

After chickpea, the same plot and layout were used for the successive crop sesame of the pattern. Seeds of two sesame varieties were sown following split-plot design on 29th March 2011 at 8 cm distances within rows of 30 cm apart. The individual and sub-plot sizes were 4 m × 5 m and 2 m × 5 m, respectively and the treatments were replicated thrice. Recommended fertilizer doses for the varieties were applied. The treatments are as follows.

Main-plot treatments: Irrigation

W_0 = No irrigation (only the use of profile soil moisture)
W_1 = One irrigation at vegetative stage (20-25 days after sowing)
W_2 = One irrigation at flowering stage (40-57 days after sowing)
W_3 = One irrigation at vegetative stage and one irrigation at flowering stage

Sub-plot treatments: Varieties

V_1 = Binatil-1
V_2 = Binatil-2 and
V_3 = BARI Til-4

Rainfall occurred and irrigation applied during the experimental period was recorded. Soil moisture was recorded at sowing, before and after irrigation, and at harvest of crop using gravimetric method and TDR (Time Domain Refectometry), technique. Profile soil moisture depletion in the control plots at 10-20 days interval was also recorded.

Mungbean

After chickpea, the same plot and layout were used for the successive crop mungbean of the pattern. Seeds of three mungbean varieties were sown following split plot design at 5 cm distances within rows of 20 cm apart. The individual and sub-plot sizes were 4 m × 6 m and 4 m × 3 m, respectively, and the treatments were replicated thrice. The treatments which were followed are as follows:

Main-plot treatments: Irrigation and mulch

W_0 = No irrigation + no mulch
W_1 = No irrigation + Mulching only (straw)
W_2 = Irrigation at vegetative stage + No mulch
W_3 = Irrigation at vegetative stage + Mulching (straw)

Sub-plot treatments: Varieties

V_1 = Binamoog-5
V_2 = Binamoog-8
V_3 = BARI Mung-5

Statistical analysis

The recorded data were analyzed following split plot design and the means were separated by least significant difference (LSD).

Economic analysis

For each cropping pattern, economic analysis was performed. Total cost of production consisted land use cost, operation cost and interest on operating capital. Land use cost was estimated using seasonal rental amount or leased value of the land used. The operating capital consisted of the cost of tillage, seed, fertilizer, irrigation, mulch, insecticide, and human labour. Interest on operating capital was charged for the period of six months at the rate of 10% per annum. Gross return was calculated by multiplying the total amount of product and by-product by their respective market prices. Net financial return was calculated by subtracting the total cost from the gross return.

Results and Discussion

Yield under cropping pattern-1

In pattern-1, rice 'Binadhan-7'was the only crop. The average yield of rice grain and straw were 4.5 and 11.8 t ha-1, respectively.

Yield as affected by different treatments in cropping pattern-2

Chickpea (Rabi season crop)

The yield and water use under different irrigation treatments are given in Table 1, Table 2 and Table 3. All yield and yield attributes were found non significant for irrigation treatments. The cultivar Binasola-4 produced the significantly highest yield (1.99 t ha^{-1}) with 3.0 cm post sowing irrigation + straw mulching (W_1) (Table 2). Irrigation water productivity were also found higher (163.95 kg $ha^{-1}cm^{-1}$) in W_1 treatment (Table 3)

Table 1. Effect of supplemental irrigation on the yield and yield attributes of Chickpea at Chowpukuria, Nachole, Chapai Nawabganj district

Treatments	Plant height (cm)	Branches $plant^{-1}$ (no.)	Pods $plant^{-1}$ (no.)	100-seed weight (g)	Seed yield (t ha^{-1})
W_0	43.89	4.33	61.31	11.31	1.60
W_1	44.58	3.98	57.59	11.96	1.81
W_2	57.24	2.89	57.49	12.09	1.84
W_3	43.47	3.89	54.73	12.05	1.61
LSD	NS	NS	NS	NS	NS
Binasola-4	57.02	3.90	57.63	12.32	1.82
Binasola-5	57.57	3.97	57.93	10.10	1.59
BARI Sola-5	42.42	3.57	51.27	13.13	1.73
LSD	NS	NS	NS	0.61	0.18

NS = not significant

Table 2. Interaction effects of irrigation and variety on the yield and yield attributes of Chickpea at Chowpukuria, Nachole, Chapai Nawabganj district

Treatments	Plant height (cm)	Branches $plant^{-1}$ (no.)	Pods $plant^{-1}$ (no.)	100-seed weight (g)	Seed yield (t ha^{-1})
$W_0 \times V_1$	44.87	5.67	74.53	12.12	1.57
$W_0 \times V_2$	44.87	4.67	48.47	10.04	1.57
$W_0 \times V_3$	41.93	2.67	60.93	11.77	1.79
$W_1 \times V_1$	57.53	2.93	48.67	11.86	1.99
$W_1 \times V_2$	57.60	4.47	63.27	10.12	1.76
$W_1 \times V_3$	42.60	4.53	54.80	13.89	1.67
$W_2 \times V_1$	57.20	2.93	44.60	12.92	1.95
$W_2 \times V_2$	46.87	2.80	44.73	10.24	1.84
$W_2 \times V_3$	43.67	2.93	47.13	13.11	1.72
$W_3 \times V_1$	44.47	4.07	54.73	12.39	1.77
$W_3 \times V_2$	44.47	3.93	67.27	10.01	1.30
$W_3 \times V_3$	41.47	3.67	42.20	13.74	1.75
LSD	NS	1.66	26.58	1.22	0.26

Table 3. Amount of supplemental irrigation, water used and water use efficiency of Chickpea at Chowpukuria, Nachole, Chapai Nawabganj district

Treatments	Irrigation water, IR (cm)	Effective rainfall, Re (cm)	Seasonal soil moisture depletion, ΔS (cm)	Water requirement*, IR + Re +ΔS (cm)	Yield ($t\ ha^{-1}$)	Irrigation water productivity ($kg\ ha^{-1}cm^{-1}$)
W_0	0	0	7.91	10.91	1.60	146.64
W_1	0	0	8.04	11.04	1.81	163.95
W_2	3	0	8.18	14.18	1.84	129.76
W_3	3	0	7.22	13.22	1.61	121.78

* Includes 3.0 cm post-sowing irrigation

Sesame (Kharif-1 crop)

The yield and water use under different irrigation treatments are given in Table 4. to Table 6. All yield and yield attributes were found non significant for irrigation treatments. The cultivars showed significant variation in yield (Table 4). The cultivar BARI Til-4 produced the highest yield (1.77 $t\ ha^{-1}$) with only 3.0 cm irrigation at vegetative stage (W_1) (Table 5).

Table 4. Effect of supplemental irrigation on the yield and yield attributes of sesame at Chowpukuria, Nachole, Chapai Nawabganj district

Treatments	Plant height (cm)	Capsule $plant^{-1}$ (no.)	Length of capsule (cm)	Seeds $capsule^{-1}$ (no.)	1000-seed weight (g)	Seed yield ($t\ ha^{-1}$)	Straw yield ($t\ ha^{-1}$)
W_0	110.64	57.24	2.92	76.62	2.83	1.57	3.69
W_1	105.57	47.16	2.92	68.53	2.85	1.51	3.42
W_2	97.20	38.51	2.96	59.84	2.95	1.39	3.28
W_3	94.73	36.22	2.93	62.29	2.86	1.41	3.11
LSD	7.63	NS	NS	9.03	NS	NS	NS
Binatil-1	98.90	37.93	4.17	67.22	3.08	1.16	3.22
Binatil-2	105.75	52.00	2.42	57.63	2.84	1.59	3.31
BARI Til-4	101.47	42.92	2.57	75.62	2.71	1.57	3.60
LSD	NS	NS	0.11	7.2	0.20	0.09	NS

NS = not significant

Table 5. Interaction effects of irrigation and variety on the yield and yield attributes of sesame at Chowpukuria, Nachole, Chapai Nawabganj district

Treatments	Plant height (cm)	Capsules plant^{-1} (nos)	Length of capsule (cm)	Seeds capsule^{-1} (nos)	1000-seed weight (g)	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})
$W_0 \times V_1$	105.60	44.47	4.26	71.87	3.02	1.16	4.07
$W_0 \times V_2$	120.20	64.00	2.33	63.73	2.94	1.57	3.29
$W_0 \times V_3$	106.13	57.27	2.17	94.27	2.52	1.63	3.71
$W_1 \times V_1$	100.07	36.13	4.21	60.80	3.07	1.17	2.89
$W_1 \times V_2$	104.13	57.60	2.50	62.13	2.87	1.58	3.56
$W_1 \times V_3$	112.53	47.73	2.21	82.67	2.63	1.77	3.81
$W_2 \times V_1$	96.33	35.00	4.05	67.53	3.14	1.16	2.97
$W_2 \times V_2$	101.53	46.33	2.57	58.67	2.80	1.60	3.32
$W2 \times V_3$	93.73	34.20	2.37	53.33	2.91	1.42	3.56
$W_3 \times V_1$	93.60	36.13	4.15	68.67	3.07	1.14	2.95
$W_3 \times V_2$	97.13	40.04	2.41	46.00	2.75	1.61	3.06
$W_3 \times V_3$	93.47	32.47	2.23	72.20	2.77	1.47	3.33
LSD	NS	NS	0.15	10.57	NS	NS	NS

NS = not significant

Table 6. Amount of supplemental irrigation, water used and water use efficiency of sesame at Chowpukuria, Nachole, Chapai Nawabganj district

Treatments	Irrigation water, IR (cm)	Effective rainfall, Re (cm)	Seasonal soil moisture depletion, ΔS (cm)	Water requirement, IR + Re +ΔS (cm)*	Yield (kg ha^{-1})	Water use efficiency (kg ha^{-1}cm^{-1})
W_0	0		-9.82	12.08	1570	120.03
W_1	0	18.9	-5.80	16.1	1510	93.78
W_2	0		-5.35	16.57	1390	83.98
W_3	0		-7.22	14.68	1410	96.05

* Includes 3.0 cm post-sowing irrigation

Yield as affected by different treatments in cropping pattern-3

Chickpea (Rabi season crop)

The yield and water use under different treatments are given in Table 7 to Table 9. All yield and yield attributes were found non-significant for irrigation treatments. The cultivars showed significant variation in yield (Table 7). The cultivar BARI Sola-5 produced the highest yield (2.60 t ha^{-1}) with 3.0 cm irrigation (W_2) (Table 8). Irrigation water productivity were found higher (264.97 kg ha^{-1}cm^{-1}) in no irrigation + mulching (W_1) treatment (Table 9).

Table 7. Effects of irrigation and mulch on the yield and yield attributes of chickpea at Chowpukuria, Nachole, Chapai Nawabganj district

Treatments	Plant height (cm)	Branches plant^{-1} (no.)	Pods plant^{-1} (no.)	100-seed weight (g)	Seed yield (t ha^{-1})
W_0	54.82	3.51	59.16	11.13	2.21
W_1	49.19	3.09	58.87	11.93	2.30
W_2	53.29	3.09	63.54	12.18	2.47
W_3	54.20	3.08	57.53	12.09	2.53
LSD	NS	NS	NS	NS	NS
Binasola-4	52.65	3.07	57.90	13.01	2.39
Binasola-5	54.18	3.30	62.15	9.78	2.33
BARI Sola-5	51.78	3.20	57.77	12.71	2.41
LSD	NS	NS	NS	0.31	NS

NS = not significant

Table 8. Interaction effects of irrigation and mulch on the yield and yield attributes of chickpea at Nachole, Chapai Nawabganj district

Treatments	Plant height (cm)	Branches plant^{-1} (no.)	Pods plant^{-1} (no.)	100-seed weight (g)	Seed yield (t ha^{-1})
$W_0 \times V_1$	54.40	3.33	44.20	13.07	2.18
$W_0 \times V_2$	57.27	3.33	58.33	9.23	2.22
$W_0 \times V_3$	54.80	3.87	74.93	11.08	2.23
$W_1 \times V_1$	47.27	2.73	54.33	13.02	2.41
$W_1 \times V_2$	52.87	3.40	69.47	9.57	2.17
$W_1 \times V_3$	47.40	3.13	52.80	13.23	2.32
$W_2 \times V_1$	57.00	2.93	64.07	12.87	2.41
$W_2 \times V_2$	54.27	3.53	76.20	10.60	2.41
$W_2 \times V_3$	50.60	2.80	50.37	13.08	2.60
$W_3 \times V_1$	53.93	3.27	69.00	13.07	2.57
$W_3 \times V_2$	54.33	2.93	44.60	9.74	2.53
$W_3 \times V_3$	54.33	3.00	53.00	13.46	2.50
LSD	NS	NS	NS	0.42	0.61

NS = not significant

Table 9. Amount of supplemental irrigation, water used and water use efficiency of chickpea at Chowpukuria, Nachole, Chapai Nawabganj district

Treatments	Irrigation water, IR (cm)	Effective rainfall, Re (cm)	Seasonal soil moisture depletion, ΔS (cm)	Water requirement, IR + Re +ΔS (cm)	Yield ($kg\ ha^{-1}$)	Water use efficiency ($kg\ ha^{-1}cm^{-1}$)
W_0	0	0	9.72	9.72	2210	227.72
W_1	0	0	8.68	8.68	2300	264.97
W_2	3	0	9.30	12.30	2470	200.81
W_3	3	0	7.66	10.66	2530	237.34

* Includes 3.0 cm post-sowing irrigation

Mungbean (Kharif-1 season crop)

The yield and water use under different irrigation treatments are given in Table 10 to Table 12. The irrigation treatments and cultivars showed non-significant variation in yield (Table 10.). The cultivar BARI Mung-5 produced the highest yield (1.38 t ha^{-1}) with natural rainfall along with 3.0 cm post-sowing irrigation ($W_2 \times V_3$) (Table 11). Irrigation water productivity were found higher (106.49 kg $ha^{-1}cm^{-1}$) in W_2 treatment (Table 12).

Table 10. Effects of irrigation and mulch practices on the yield and yield attributes of mungbean at Chowpukuria, Nachole, Chapai Nawabganj district

Treatment	Plant height (cm)	Branches $plant^{-1}$ (no.)	Pods $plant^{-1}$ (no.)	Pod length (cm)	Seed pod^{-1} (no.)	1000-seed weight (g)	Seed yield ($t\ ha^{-1}$)	Straw yield ($t\ ha^{-1}$)
W_0	59.29	2.38	29.42	8.12	10.24	35.53	1.19	2.87
W_1	65.26	2.20	28.49	8.28	10.98	35.68	1.17	3.11
W_2	65.93	2.38	31.00	8.33	10.89	35.61	1.28	2.85
W_3	46.42	2.12	27.44	7.98	10.27	36.66	1.18	2.94
LSD	6.63	NS	1.84	NS	NS	0.77	NS	NS
Binamoog-5	60.78	2.48	29.22	8.41	10.57	33.35	1.16	2.96
Binamoog-8	57.22	2.40	30.29	8.35	10.80	39.08	1.20	2.88
BARI Mung-5	59.68	2.12	27.76	7.78	10.43	35.17	1.26	2.98
LSD	NS	0.28	1.68	0.29	NS	2.47	NS	NS

NS = not significant

Table 11. Interaction effects of irrigation and conservation practices on the yield and yield attributes of mungbean at Chowpukuria, Nachole, Chapai Nawabganj district

Treatments	Plant height (cm)	Branches plant^{-1} (no.)	Pods plant^{-1} (no.)	Pod length (cm)	Seeds pod^{-1} (no.)	1000-seed weight (g)	Sees yield (t ha^{-1})	Husk yield (t ha^{-1})
$W_0 \times V_1$	64.40	2.60	31.73	8.26	10.07	31.37	1.12	2.95
$W_0 \times V_2$	53.20	2.60	29.43	8.15	10.27	39.30	1.21	2.89
$W_0 \times V_3$	60.27	1.93	27.10	7.96	10.40	35.93	1.26	2.75
$W_1 \times V_1$	64.57	2.67	27.13	8.73	11.07	32.47	1.14	3.24
$W_1 \times V_2$	64.40	2.00	31.00	8.57	11.47	39.07	1.13	3.03
$W_1 \times V_3$	66.80	1.93	27.33	7.57	10.40	35.50	1.25	3.07
$W_2 \times V_1$	66.47	2.47	30.80	8.61	10.67	33.70	1.19	2.70
$W_2 \times V_2$	66.40	2.33	33.07	8.69	11.47	38.53	1.28	2.82
$W_2 \times V_3$	64.93	2.33	29.13	7.69	10.53	34.60	1.38	3.03
$W_3 \times V_1$	47.67	2.20	27.20	8.04	10.40	35.87	1.20	2.93
$W_3 \times V_2$	44.87	2.67	27.67	8.00	10.00	39.43	1.17	2.79
$W_3 \times V_3$	46.73	2.27	27.47	7.91	10.40	34.67	1.17	3.10
LSD	NS	NS	NS	0.43	NS	NS	NS	NS

NS = not significant

Table 12. Amount of supplemental irrigation, water used and water use efficiency of mungbean at Chowpukuria, Nachole, Chapai Nawabganj district

Treatments	Irrigation water, IR (cm)	Effective rainfall, Re (cm)	Seasonal soil moisture depletion, ΔS (cm)	Water requirement, IR + Re + ΔS (cm)*	Yield (kg ha^{-1})	Water use efficiency (kg ha^{-1}cm^{-1})
W_0	0	18.90	-6.93	14.97	1190	79.49
W_1	0		-8.86	13.04	1170	89.72
W_2	0		-9.88	12.02	1280	106.491
W_3	0		-7.60	14.30	1180	82.52

* Includes 3.0 cm post-sowing irrigation

Net profit under different cropping patterns

Net profit under different cropping patterns along with associated management practices and cultivars are summarized in Table 13. It is evident that the cropping pattern-3 produced the highest net financial benefit, with the irrigation water requirement (6 cm) similar to cropping pattern-2. The cultivars with this pattern are: 'Binadhan-7' for transplanted Aman rice, 'Binasola-4' for chickpea, and 'Binamoog-5' for mungbean. It is evident that applying 6 cm water in dry-season crops chickpea and mungbean, a net profit of BDT 1,38,850/= (US$ 1,734) can be obtained, which is BDT 94,468/= (US$ 1,181) higher than the existing local practice.

Table 13. Net profit under different cropping patterns and with associated management practices and cultivars (average of 2 years)

	Total irrigation amount applied (cm)	Management practice (mulching)	Net profit (Tk ha^{-1})
Pattern-1 (Rice-Fallow-Fallow) [Local cultivar – Sumon]	0	No mulch (Normal)	44,382/=
Pattern-1 (Rice - Chickpea - Sesame) [Binadhan-7 – Binasola-4 – Binatil-1]	6 (0+ 3+3)	No – Mulch – No	1,22,705/=
Pattern-1 (Rice -Chickpea - Mungbean) [Binadhan-7 – Binasola-4 – Binamoog-5	6 (0+ 3+3)	No – Mulch – No	1,38,850/=

Note: 1 US$ = 80 BDT

Conclusion

Occurrence of timely rainfall in sufficient quantity is the prime requirement for successful rain-fed agriculture. Insufficient rainfall during dry season attracts the need of in situ soil moisture conservation, water harvesting and supplemental irrigation. The study has been conducted at Barind tract area of Bangladesh with the objective of assessing the possibilities for having an additional crop yield by appropriate crop and soil-water management plan. The study explores the best technical option to resolve the constraints related to water management in rain-fed farming. Comparative study of *in situ* soil moisture conservation techniques in farmer's field with possible combination of crops for the area had been conducted from June 2009 to October 2011.

After the harvest of short duration T. aman rice in October, the profile soil moisture was utilized and also mulching was done by rice straw to conserve the stored profile soil moisture. In addition, light supplemental irrigation that was needed thereafter, was applied from available surface water sources (pond). The practice facilitated two additional crops in the area with much profitability. The best practice identified is: 'Binadhan-7' for transplanted Aman rice, 'Binasola-4' for chickpea, and 'Binamoog-5' for mungbean. A net profit of BDT 1,38,850/= (US$ 1,734) can be obtained from this practice applying 6 cm water in dry-season crops chickpea and mungbean, which is BDT 94,468/= (US$ 1,181) higher than the existing local practice. This practice/technology showed be extended/ disseminated over the area for the better livelihood of the farmers and food security of the country.

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References

Alam, M. K., Hossain, A. K. M. S., Khan, M. R. and Whitney, J. W. 1990. Geological map of Bangladesh. Geol. Surv. Bangladesh, Dhaka.

Ali, M. H., Sarkar, A. A. and Rahman, M. A. 2012. Analysis on groundwater-table declination and quest for sustainable water use in the North-western region (Barind area) of Bangladesh. J. of Agril. Sci. and Applications. 1(1): 26-32.

Ali, M. H., Amin, M. G. M. and Islam, A. K. M. R. 2005a. Reference evapotranspiration over Bangladesh and its implication in crop planning. J. Bangladesh Agril. Univ., 3(1): 139-147

Ali, M. H., Hoque, M. R., Hassan, A. A. and Khair, M. A. 2007. Effects of deficit irrigation on wheat yield, water productivity and economic return. Agric. Water Manage., 92: 151-161.

Ali, M. H., Hoque, M. R., Hassan, A. A. and Khair, M. A. 2008. Effective management of water in wheat cultivation under water-limiting condition. J. of the Institution of Engineers, Bangladesh, Vol. 34/AE, 1-11.

Ali, M. H. and Adham, A. K. M. 2007. Impact of climate change on crop water demand and its implication on water resources planning. J. Agrometeorol., 9(1): 20-25.

Ali, M. H. and Talukder, M. S. U. 2008. Increasing water productivity in crop production- A synthesis. Agric. Water Manage. 95: 1201-1213.

Ali, M. H., Amin, M. G. M. and Islam, A. K. M. R. 2005b. Probability analysis of monsoon and off-monsoon rainfall and crop planning in Bangladesh. Bnagladesh J. Env. Sci., 11(2): 290-295.

Hassan, A. A., Ali, M. H., Karim, N. N. and Sarkar, A. A. 2000. Effect of irrigation on the yield-water relations of mustard. Bangladesh J. Agric., 25(1&2): 51-61.

Hassan, A. A., Karim, N. N., Hamid, M. A. and Salam, M. A. 2003. Soil water management and conservation practices towards a new cropping pattern in drought areas of Bangladesh. Pak. J. Agron., 2(2): 77-84.

Jahan, C. S., Islam, M. A., Mazumder, Q. H. Asaduzzaman, M., Islam, M. M., Islam, M. O. and Sultana, A. 2005. Evaluation of depositional environment and aquifer condition in the Barind area, Bangladesh, using gamma ray well log data. J. Geol.Soc. India, 70: 1070-1076.

Sarkar, A. A., Hassan, A. A., Ali, M. H. and Karim, N. N. 2002. Effect of deficit irrigation at different growth stages on the yield of potato. Pak. J. Bio. Sci., 5(2): 128- 134.

Sarkar, A. A., Hassan, A. A., Ali, M. H. and Karim, N. N. 2000. Yield potential of lentil under different soil moisture status. J. of the Institution of Engineers, Bangladesh, 27(1): 35-42.

Sarkar, A. A., Ali, M. H. and Rahman, M. A. 2010. Long-term water-table dynamics of Rajshahi district and its prediction using MAKESENS model. A Research Report, BINA/Ag. Engg. Division-9, Bangladesh Institute of Nuclear Agriculture, p. 22.

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PARTICIPATORY VARIETAL SELECTION OF BORO RICE VARIETY FOR COASTAL AREAS OF BANGLADESH

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Abstract

Millions of hectares of rice lands are technically suited for rice production but are left uncultivated or are grown with very low yields because of soil salinity and problem soils. About 53% of the coastal areas are affected by salinity due to inundations from the sea, and intrusion of sea water through rivers, estuaries, etc. The study was conducted in the saline areas of Bangladesh to find out the best variety/mutant line and other performance in the coastal areas of this country. To assess the performance of the variety PRA, preference analysis and correlation analysis were done. It was observed that among the rice variety/lines, Binadhan-8 showed the utmost performance i.e., grain yield of the variety was the highest in all the studied areas. So, this variety could be suggested for cultivation in the saline areas of Bangladesh.

Key words: Binadhan-8, Salinity, Preference analysis

Introduction

Rice is the staple food for more than half of the world's population, especially in Bangladesh. Rice production significantly increased over the past few years (276.84 metric tons in 2003-04 and 369.36 metric tons in 2009-'10) but the number of the population also increased during this period (BBS, 2010). To meet the increased need, it is urgent to find out such type of rice variety which can cope with stresses as; salinity, submergence and drought (David *et al*., 2010). The prospect of global warming resulting from accumulation of greenhouse gases is causing major concern, especially in connection with its potential effect on rice production (Wassmann *et al.,* 2009). Binadhan 8 is a salt tolerant rice variety, which can tolerate 12-14 dS/m salt at seedling stage and 8-10 dS/m salt at maturity stage. Duration of this variety is 130-134 days. Participatory variety selection is an approach to provide choices of varieties to the farmers for increasing production in their diversity of socio-economic and agro-ecological condition. Binadhan-8 was selected in the field by voting (male and female) system using preference analysis.

The study was designed to identify the best variety/mutant line, assess the acceptability of crop varieties/mutant lines, identify the consumer's preference (cooking quality, grain shape-size, aroma, tastiness, etc.) and determine the economic constraints of the worst varieties/mutant lines. First activity was evaluation of promising salt tolerant germplasm in multi-location trials in farmer's field.

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Materials and Methods

The study was conducted based on primary data at Labanchara upazilla of Khulna, Kaligang and Shamnagar upazillas of Satkhira district during the T. aman season of 2011. In total 90 farmers were selected for the study taking 30 farmers in each area. In the sampled areas, data were collected through pre-designed interview schedule. In Labanchara, nine advanced rice lines with one salt tolerant check variety (Binadhan-8), in Kaligang and Shamnagar one advanced rice line with one salt tolerant check variety (Binadhan-8) were considered for the study. The design of the experiment was Randomized Completely Block (RCB) design with three replications. Farmer's preferences were considered on the characters of good yield, salt tolerant, long panicle, more number of tillers in a hill, attractive color of grain, fine grain, etc. In the study, the preference analysis and the correlation analysis were done for analyzing the collected data.

Results and Discussion

From Table 1, it was found that Binadhan-8 achieved the highest vote and advanced line P19S8 scored the second highest vote followed by P24L2. Though the line P19S8 received a reasonable number of the farmer's vote, the yield of line P19S8 was not satisfactory as the grain quality was not so good.

Table 1. Preference analysis of mother trial of salt tolerant lines/germplasms at Labanchara, Khulna during the T. aman season of 2011

Entry		Total farmers (n = 30)		Preference score	Grain yield ($t\ ha^{-1}$)
Code	Name	Positive	Negative		
PVS1	P27S5	0	29	-0.242	1.99
PVS2	P36S5	0	26	-0.217	1.45
PVS3	P25S1	0	1	-0.008	2.54
PVS4	P1L1	0	3	-0.025	2.72
PVS5	P29S7	0	1	-0.008	3.08
PVS6	P1L2	0	0	0.000	3.63
PVS7	P24L2	3	0	0.025	3.99
PVS8	P1L3	0	0	0.000	1.27
PVS9	Binadhan-8	29	0	0.242	4.53
PVS10	P19S8	28	0	0.233	2.72

Male (n = 19), Female (n = 11) and Researcher (n = 2)

Binadhan-8 produced the highest grain yield (4.53 $t\ ha^{-1}$) followed by P24L2, P1L2, P29S7, P19S8, P1L1, P25S1, P27S5, P36S5 and P1L3. Preference score of salt tolerant lines/germplasms, Binadhan-8 was the highest (0.242) followed by P19S8, P24L2, P1L2 and P1L3. The preference level of P27S5, P36S5, P25S1, P1L1, P29S7 showed with negative sign.

From Table 2, it was observed that correlation between male and female farmers was the highest followed by correlation of farmers and researchers, farmers and yields in the mother trial of salt tolerant line/germplasms at Labanchara, Khulna. It was also observed at Labanchara, Khulna district the correlation was significant with positive sign at 10 and 1 per cent significance level.

Table 2. Correlation analysis of mother trial of salt tolerant lines/germplasms at Labanchara, Khulna during the T. aman season of 2011

Variables	Correlation	Significance level
Male and female farmers	r = 0.99 ***	significant
Farmers and researchers	r = 0.95 ***	significant
Farmers and yields	r = 0.62 *	significant

*significant at 10% level, ***significant at 1% level of probability

In Table 3, it showed that the check variety Binadhan-8 performed well with the highest grain yield (2.08 t ha^{-1}) and got all 30 positive votes from the farmers because of having this variety the highest effective tiller, long panicle and errect and green flag leaves.

Table 3. Preference analysis of Mother trial of salt tolerant lines/germplasms at Kaligonj, Satkhira during T. aman season of 2011

Entry		Total Farmers (n = 30)		Preference score	Grain yield (t ha^{-1})
Code	Name	Positive	Negative		
PVS1	P27S5	0	21	-0.175	0.33
PVS11	Binadhan-8	30	0	0.250	2.08

From Table 4, it was found that correlation among the mother trial of salt tolerant line at Kaligonj was positively significant at 5 per cent and 1 per cent level. Correlation between male and female farmers was the highest followed by farmers and researchers, farmers and yields.

Table 4. Correlation analysis of mother trial of salt tolerant lines/germplasm at Kaligonj, Satkhira, during the T. aman season of 2011

Variables	Correlation	Significance level
Male and female farmers	r = 0.79 ***	Significant
Farmers and researchers	r = 0.71 **	Significant
Farmers and yields	r = 0.68 **	Significant

**significant at 5% level, ***significant at 1% level of probability

From Table 5, it was observed the that check variety Binadhan-8 also exhibited its superior performance at Shyamnagor and got all 30 positive votes along with the highest 5.0 t ha^{-1} grain yield. In terms of farmer's preference, salt tolerant line P27S5 was the second best among the tested entries.

Table 5. Preference analysis of mother trial of salt tolerant lines/germplasms at, Shyamnagar, Satkhira during the T. aman season of 2011.

Entry		Total farmers (n = 30)		Preference score	Grain yield (t ha^{-1})
Code	Name	Positive	Negative		
PVS1	P27S5	0	22	-0.183	0.48
PVS11	Binadhan-8	30	0	0.250	5.00

Male (n = 20), Female (n = 10) and Researcher (n = 1)

From Table 6, it was identified that correlation between male and female farmers among the mother trial of salt tolerant line/germplasms at Shyamnagar of Satkhira district was the highest followed by farmers and researchers, farmers and yields. It was also observed that correlation among the mother trial of salt tolerant line/germplasms at Shyamnagar of Satkhira district was significant with positive sign at 1 per cent significance level.

Table 6. Correlation analysis of mother trial of salt tolerant lines/germplasms at Shyamnagar, Satkhira during the T. aman season of 2011.

Variables	Correlation	Significance level
Male and female farmers	r = 0.87 ***	Significant
Farmers and researchers	r = 0.80 ***	Significant
Farmers and yields	r = 0.77***	Significant

***significant at 1% level of probability

Conclusion

From the finding, it could be concluded that Binadhan-8 exhibited the utmost performance in all studied areas. Grain yields of Binadhan-8 were 5.00, 4.53, 2.08 t ha^{-1} at Shyamnagar, Labanchara and Kaligang upazilla, respectively which was the highest production over the other rice lines. Therefore, its cultivation could be expanded in the saline areas of Bangladesh.

References

BBS, 2010. The Year Book of Agricultural Statistics of Bangladesh, Bangladesh Bureau of Statistics, Statistics Division, Ministry of Finance and Planning, Government of the Peoples' Republic of Bangladesh, Dhaka, Bangladesh.

David J., Mackill A., Ismail M., Alvaro M., Pamplona, Darlene L., Sanchez, Jerome J., Carandang and Endang, M. 2010. Stress Tolerant Rice Varieties for Adaptation to a Changing Climate. International Rice Research Institute, Metro Manila, Philippines.

Wassmann, R., Jagadish, S.V. K., Sumfleth, K., Pathak, H., Howell, G., Ismail, A., Serraj, R., Redona, E., Singh, R. K., Heuer, S. and Donald, L. S. 2009. Regional vulnerability of climate change impacts on Asian rice production and scope for adaptation. *In*: Advances in Agronomy. Academic Press, pp. 91-133.