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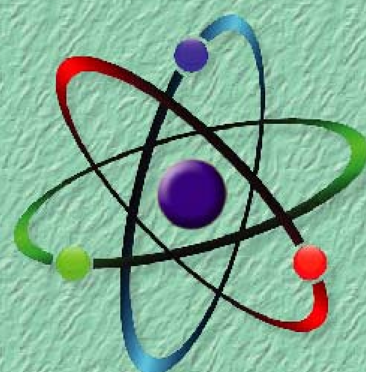

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DEVELOPMENT OF AN ENERGY AND DIRECTIONAL INDEPENDENT NEUTRON DOSE MONITOR

S. H. Bhuiya[1], H. Yamanishi[2], T. Uda[2], N. Sultana[3] and K. S. Arefin[1]

Abstract

An energy and directional independent neutron ambient dose equivalent monitor was developed in order to obtain improved dose response over a wide energy range of neutrons compared to the existing instruments. The monitor was four-layered spherically shaped, arranged in the order of from outer to inner; poly-methyl methacrylate (PMMA), boron nitride (BN), polyethylene (PE) and core PE. Twelve radial directional TLDs were arranged at two different depths and one in the centre. Monte Carlo N-particle transport code, MCNP5 was used for the design of the monitor. Neutron cross-section libraries of Japanese Evaluated Nuclear Data Library, JENDL-3.3 were applied for the calculation. The calculation was performed to get the TLDs responses considering the reaction of ^{6}Li (n, α) T. The neutron dose was evaluated from the responses of the linear combination of TLDs and linear co-factors. To adjust the dose response of the monitor, the spectrum of the D_2O moderated ^{252}Cf source with 52 energy bins ranging from 0.414eV to 15MeV was used. The dose response was improved and well agreed with the expected dose than that of the existing instruments. The directional sensitivity of the monitor to neutrons was found almost isotropic. In order to verify the usefulness of evaluation for neutron ambient dose equivalent *H**(10) by the developed monitor, several irradiation experiments were conducted at Facilities for Radiation Standardization (FRS), Japan Atomic Energy Agency (JAEA). The D_2O moderated ^{252}Cf source was used for the calibration of the monitor. A linear relationship was obtained between the TLD readout data and MCNP calculated value for the same geometry of irradiation. Neutron dose was also evaluated from the irradiation experiments of ^{252}Cf bare and ^{241}Am-Be sources. The obtained evaluated dose for each irradiation was close to the actual irradiated dose. Thus, the developed monitor can be used for the application of area monitoring irrespective of the energy and incident direction of neutron.

Key words: Ambient dose equivalent, Energy, *H**(10), MCNP, Monitor, Neutron, TLD

Introduction

Monitoring is required at the workplaces of neutron producing fields; like nuclear fusion facilities, nuclear power plants, accelerator facilities, nuclear fuel reprocessing plants and radio-isotopes of neutron, etc. The dose equivalent is used in radiation protection to account for the effectiveness of the radiation. The quality factor Q, is a

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modifier used in converting absorbed dose to dose equivalent. The factor that applied for the measurement of ambient dose equivalent, varies significantly with neutron energy that was recommended in International Commission for Radiological Protection (ICRP) publication 60 (ICRP, 1991). At neutron workplaces, neutrons are present with wide energy ranges from thermal to tens of MeV (Alberts *et al.,* 1996). Each energy groups of neutrons should be considered during dose evaluation. Therefore, neutron measurement instrument is essential for monitoring the dose precisely over a wide energy range of neutron that is present at workplaces.

Rontegen Equivalent Man (REM) counters are widely used for a long time to monitor neutron ambient dose equivalent. These are based on the ^{3}He proportional counter placed at the center, surrounded by a moderator made of a hydrogenous material, usually polyethylene. The shape of the moderator is either cylindrical or spherical with a suitable size that can sufficiently moderate the neutrons with energies ranging from fast to thermal. However, it is recognized that almost all the currently used REM counters have some limitations. Their dose response typically includes an error, especially in the intermediate energy range around 0.1keV–100keV (Burgkhardt *et al.,* 1997; Klett *et al.,* 1997; Bartlet *et al.,* 1997). The intermediate energy of the neutrons contributes significantly to the ambient dose equivalent at workplaces (Mill, 1982). In order to improve the dose response over a wide energy range of neutrons than that of the existing instruments, a multi-layered neutron dose monitor was designed using multiple detectors. Besides the neutron energy distribution, it is also important to consider the directional distribution of neutron fluence of the monitor. Therefore, multiple TLD detector based spherical neutron monitor was developed in order to perform better dose response, with uniform response to wide energy of neutrons and equal sensitivity to neutrons coming from any direction. The monitor was based on neutron moderation-absorption technique, sensitive to measure three different energy groups at three depths of moderator. It is assumed to perform better dose response than the existing instruments. Neutron dose from low, intermediate and fast energies can be evaluated precisely using this monitor. According to the design, the prototype monitor was constructed and several irradiation experiments were performed at reference field of FRS, JAEA for evaluating the neutron dose.

Configuration of the Instrument

Structure of the layers

Based on the moderation and absorption technique and considering the thicknesses of REM counters and Bonner spheres (Leake, 1968, Bramblett *et al.,* 1960), at first the three layered one dimensional (1-D) monitor (outermost PE+ BN +

core PE) was designed with total thickness of 10~12 cm. Three depths of TLDs; TLD_1, TLD_2 and TLD_3 were used in order to know the specific energy responses of low, intermediate energies and fast neutrons, respectively. TLD_1 detected the moderated thermal neutrons at first depth of the detectors. The first depth of the monitor's layer was chosen 20 mm thick polyethylene (PE) to get the similar response as 2~3 cm thickness of PE (Johnson *et al.,* 1987), which makes flat energy response to low energy of neutrons. In order to limit the energy sensitivity of the second depth of the detectors, mainly to intermediate energies of neutrons ranging from 1keV to 100 keV neutrons, the thickness of the boron nitride (BN) layer was chosen as 35 mm (Yamanishi *et al.,* 2004). Intermediate energies of neutrons became slowdown with interaction of the first depth of 20 mm thick PE and passed through 35 mm thick of BN. The thermalized intermediate energies of neutrons were detected by TLD_2. TLD_3 detected the thermalized fast neutrons at core depth of the detector. In the three layers monitor, the sensitivity of the intermediate energies at second depth of detectors was found too small to evaluate the dose. Therefore, the monitor's design was converted from three layers to four layers by using an additional 10 mm PE after BN layer. The 10 mm of PE prevented the direct absorption of thermal neutrons near the TLD_2 by BN layer.

Arrangement of TLDs in 12 radial axes

Although PE was considered as first layer of the instrument, the Poly methyl methacrylate (PMMA) with chemical form of $-(C_5O_2H_8)_n-$ also have hydrogenous material for neutron moderation and more suitable to manufacture the spherical shell of first layer of the monitor precisely than PE. Therefore, finally PMMA was selected as first layer of the three dimensional (3-D) monitor. Using atomic density of hydrogen, the thickness of the PMMA was converted to 30 mm comparing with 20 mm thickness of PE. A two-dimensional view of the 3-D monitor is shown in Fig. 1. Including the gaps of TLDs setting, the monitor with thickness of 30 mm PMMA + 35 mm BN + 10 mm PE + 35 mm PE was found to be about 27.0 cm diameter, as shown in Fig. 1.

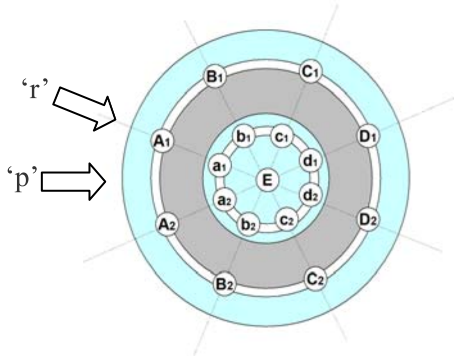

Fig. 1. Two dimensional view of the monitor (A, B, C, D, a, b, c, d and E are TLD detectors)

According to the three dimensional arrangement, the series of TLD_1 and TLD_2 (12 nos. each) were placed between layers along 12 radial axes at even intervals, corresponding to the apexes of a regular polyhedron with 20 triangular faces, as shown in Fig. 2. An example of the face of triangle is '$A_1A_2A_3$'. Since any three adjacent apexes form an equilateral triangle, the arrangement of the TLDs was almost uniform in all directions. A single detector of TLD_3 was placed at the center of the moderator. The total number of TLDs was 25. According to the shape of the monitor as well as the arrangement of TLDs, it could be assumed that the sensitivity of the instrument would be uniform and equal that neutrons coming from any direction.

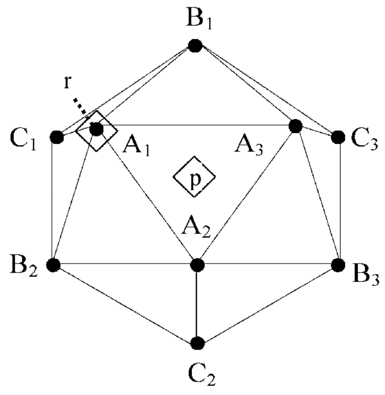

Fig. 2. Twelve radial directions of detectors A_1-D_3 means the axes of the 1st and 2nd layers, D_1-D_3 are behind, and center E is inside with two neutron incident directions ('p' and 'r')

Three sets of TLDs were used at three depths of the moderators and absorber to measure the dose from different energy groups; low and intermediate energies and fast neutrons. Considering the incident direction of the neutron, 9 groups of TLDs 'A', 'B', 'C', 'D', 'a', 'b', 'c', 'd' and 'E' were categorized for the calculation. Each group of detectors through 'A' to 'd' consisted of three detectors. As an example, 'A' group was formed by three TLDs of category A (A_1, A_2 and A_3). TLD group 'E' was formed by a single detector. Three depth levels were used for the arrangement of three series of detectors, TLD_1 (A, B, C, and D), TLD_2 (a, b, c, and d) and TLD_3 (E).

Materials and Methods

MCNP calculation

Three sets of TLDs were used at three depths of the moderator to measure the dose from different energy groups; low and intermediate energies and fast neutrons. Each TLD was formed with composition of $CaSO_4$ (Tm) and ^6LiF. This indicated that the mixture of $CaSO_4$ (Tm) and ^6LiF in powder form was sealed in a glass ampoule (2 mm Ø × 12 mm). The responses of TLDs were calculated using the Monte Carlo N-particle transport Code, MCNP5 (X-5 Monte Carlo Team, 2003). Neutron cross-section libraries of Japanese Evaluated Nuclear Data Library, JENDL-3.3 were applied for the calculations (Nuclear Data Center, http://wwwndc.jaea.go.jp). In order to evaluate the dose response of the monitor, the spectrum of the D_2O moderated ^{252}Cf source was chosen as mentioned in the International Organization of Standardization, ISO8529 (ISO8529, 1989), because it is the standard source of ISO which contains low and intermediate energies and fast neutrons. Therefore, its spectrum can be considered to be a representative of the workplace. The wide energy of neutrons is more suitable for the calibration of instrument. The neutron incident energies from 0.414 eV to 15 MeV of 52 energy bins that provided by the ISO8529 were calculated to get the TLDs responses. The response of each TLD was calculated from the reaction of ^{6}Li (n, α) T. A parallel neutron beam of 15 cm radius with uniform density was injected to the surface of the monitor. The number of neutron was 25×10^7 and the relative error was less than 0.05.

Directional sensitivity of neutrons

In order to examine the directional sensitivity of the monitor, two neutron incident directional points 'p' and 'r' were chosen for the calculations. One triangle, '$A_1A_2A_3$', formed by three detectors, as shown in Fig. 2, was considered as the representative, because an equilateral triangle could be assumed as the basic unit of this monitor. The two incident directions are point 'p', which is the median of triangle '$A_1A_2A_3$', and point 'r' where the neutrons were inserted through detector 'A_1'. The neutron direction 'r' was selected to check whether the sensitivity of the monitor was equal to that neutrons coming from any angular direction compared to the sensitivity of the 'p' directional incident neutrons. The selection of two incident directions was enough to check the neutrons directional sensitivity, because the distance of point 'r' from the median of equilateral triangle '$A_1A_2A_3$' was large than any other point inside the triangle.

Irradiation experiment at FRS, JAEA

The D_2O moderated ^{252}Cf source was used for the calibration of the instrument at FRS, JAEA. This type of source was installed at various calibration facilities (Ing and Cross. 1984; Kowatari *et al.,* 1997; Jetzke and Kluge, 1997; Yoshizawa *et al.,* 2004).

It consists of 30-cm inside-diameter of heavy water (D_2O) sphere, surrounded by a fixed stainless steel shell of 0.8 mm thick walls. The sphere was also covered with a removable 1.0 mm cadmium shell, which was used to absorb thermal neutrons. The cylindrical ^{252}Cf source was positioned inside the sphere so that the center of the source and the center of the D_2O sphere to become same. The size of the irradiation room of JAEA, FRS is 12.5 m ×12.5 m × 11.7 m and the neutron source is positioned at the centre of the room. Irradiation experiments were also conducted using ^{252}Cf bare and ^{241}Am-Be neutron, in order to compare the evaluated doses among the different energy spectrum of neutrons.

In order to examine the directional sensitivity of the monitor; as shown in Fig. 2, two incident directions of neutrons were chosen for the irradiation. The direction ‘p’ which is the median of the triangle formed by three detectors of A_1, A_2, and A_3 and another is direction ‘r’ where neutrons were inserted to one of the detector A_1. The irradiation conditions are shown in Table 1. The irradiation doses and time were forecasted from the result of the test experiment that was conducted at National Institute for Fusion Science (NIFS) using a ^{252}Cf source. The irradiation name was specified using the name of source, irradiation distance and neutron incident direction. As an example, the name D_2O-75-p means the irradiation was performed using D_2O-moderated ^{252}Cf source at a center-to-center distance of 75 cm between source and the monitor for ‘p’ directional incident of neutrons.

Table 1. Irradiation conditions at FRS, JAEA

Irradiation Name	Irradiation distance (cm)	Neutron incident direction	Neutron emission rate (s^{-1}) On calibration date	Neutron emission rate (s^{-1}) On experimental date	Date of experiment	Irradiation time	Irradiated dose (mSv)
D_2O-75-p	75	p	[a] 1.88×10^7 (2003.12.16)	6.23×10^6 (2008.3.3)	2008.3.3~6	49 hrs. 20 min.	1.48
D_2O-75-r	75	r	[a] 1.88×10^7 (2003.12.16)	5.46×10^6 (2008.9.8)	2008.9.8~12	34 hrs. 30 min	0.93
Cf-75-p	75	p	[b] 2.52×10^8 (1999.3.7)	2.40×10^7 (2008.3.3)	2008.3.3	2 hrs. 40 min.	1.25
Cf-150-r	150	r	[c] 2.15×10^8 (2008.1.28)	1.84×10^8 (2008.9.2)	2008.9.2	2 hrs.	1.85
AmBe-75-p	75	p	[d] 2.41×10^6 (2002.12.18)	2.39×10^6 (2008.9.2)	2008.9.2~3	11 hrs.	0.52

[a]Nominal activity: 199.8MBq; [b]Nominal activity: 2GBq; [c]Nominal activity: 2GBq; [d]Nominal activity: 37GBq

Results and Discussion

Calculated dose response

The response of TLD in each energy groups was calculated. The energy response of each TLD varied with moderation and absorption. It was expected to vary the detector response from different energy ranges of neutrons. The expected reading of each TLD corresponded to the product of the energy response and neutron fluence. The ambient dose equivalent was calculated from the linear combination of TLD group response using Eq. (1) (i = A, a, B, b, C, c, D, d and E, as shown in Fig. 1 and N = 3, 5, 7 and 9 groups).

$$D_j = \sum_{i}^{N} \alpha_i R_{ij} \qquad (1)$$

where, D_j is the dose from *j*th energy bin, α_i is the linear co-factors of *i*th groups and R_{ij} is the TLD response of *i*th groups with *j*th energy bin. According to the neutron energy bins, 52 linear combination equations was considered. It was assumed to be the good dose response for linear combination factors using the least square method comparing with the detector responses and the ideal dose curve. Finally, the linear combination factors α_i was found using the expected response and expected dose from the standard neutron source. The dose response of the monitor was evaluated using D_2O moderated ^{252}Cf sources of 30 cm diameter of sphere. The fluence of each energy range was provided by ISO8529 (ISO8529, 1989).

An example of calculated energy response for 5 groups of TLD detectors for three different neutron energies could be found in Fig. 3. Re (A) and Re (B) were the responses for low, Re (a) and Re (b) for intermediate, while Re (E) was the response for fast energy of neutrons. The ratio of dose response to the *H**(10) using ICRP-74, is shown in Fig. 4 (ICRP, 1996).

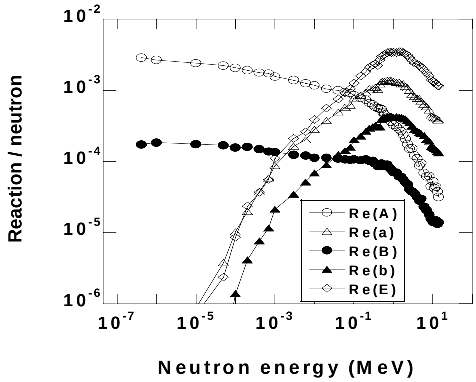

Fig. 3. Reaction rate of TLD detectors at different depths of the moderator

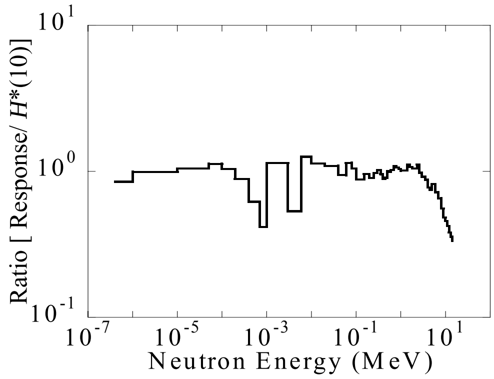

Fig. 4. Ratio of expected dose to *H**(10) from D_2O moderated ^{252}Cf source (N = 5, i = AaBbE)

The values varied from 0.42 to 1.26 in the energy less than 1 MeV and from 1.11 to 0.33 more than 1 MeV. The dose response was found to be good compared to the existing instruments, especially at the range of intermediate energy of neutron (Burgkhardt *et al.,* 1997; Klett *et al.,* 1997; Bartlet *et al.,* 1997). It was also found that the total ambient dose equivalent varied 3% between two incident directions on neutrons ‘p’ and ‘r’ as mentioned in Fig. 1.

Calibration with D_2O moderated ^{252}Cf source

The response of the TLDs was calculated for the irradiation of D_2O moderated ^{252}Cf source using MCNP5 (X-5 Monte Carlo Team, 2003) at the same geometry of D_2O-75-p irradiation. The reaction of each TLD was ^{6}Li (n, α) T for the calculation. The incident energy was ranging from 0.414eV to 15MeV with 52 energy bins. A linear relationship between the experimental readout data (R_i*) and the MCNP calculated responses (R_i) was obtained, as shown in Fig. 5. Based on Fig. 5, the relationship between measured data and calculated response was written in Eq. (2), where c and ε are the constant values of 3.99 and 0.0641, respectively and i is the name of TLDs groups; i =A, B, C, D, a, b, c, d, and E.

$$R_i^* = c + \varepsilon R_i \qquad (2)$$

The ambient dose equivalent was calculated from the linear combination of Eq. (3) where, D is the calculated dose, i is the name of TLD detector groups; i =A, B, C, D, a, b, c, d, and E, N is the number of selected TLD group set. When N is selected 3 then i = A, a, E. Similarly, for 5 and 7 then i = A, a, B, b, E and i = A, a, B, b, C, c, E, respectively. R_i is the response of the TLDs of i group.

$$D = \sum_i^N \alpha_i R_i \qquad (3)$$

The D_2O-moderated ^{252}Cf source was used for the determination of co-factors, because of its wide energy spectrum. The neutron dose for 52 energy bins was calculated using the Eq. (4).

$$D = \sum_j^{52} D_j = \sum_j^{52} \sum_i^{N} \alpha_i R_{ij} \qquad (4)$$

where, j is the 52 energy bins given in the ISO8529 corresponding to the fluence of the source, D_j is the expected dose of j energy bins was found by multiplying the fluence and fluence to dose conversion co-efficient of ICRP publication 74 (ICRP, 1996) and R_{ij} is the response of i groups of TLDs of j energy bins obtained by MCNP calculation. The linear co-factors α_i were derived by the matrix equation of Eq. (5).

$$[\alpha_i] = \lfloor D_j \rfloor \, [R_{ij}]^{-1} \qquad (5)$$

The source intensity was different between experimental and MCNP calculation. Therefore, the calculated value was adjusted with the neutron intensity, in order to fit the experimental dose of 1.48mSv. Using Eqs. (2) and (3), the equations of neutron ambient dose equivalent and error were derived as Eq. (6) and (7), respectively;

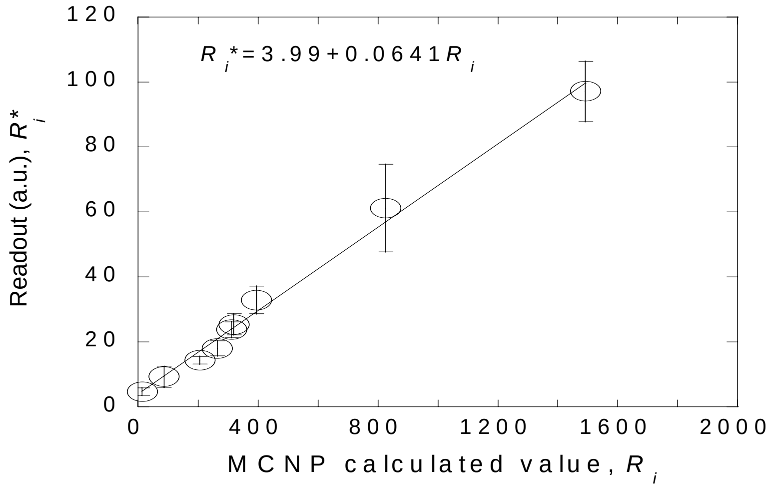

Fig. 5. Linear relationship between measured and calculated response for the fluence of D_2O-moderated ^{252}Cf source (9 groups of TLD detectors) considering 1.48mSv dose

$$D = \sum_{i}^{N} \alpha_i (R_i * - c) / \varepsilon \qquad (6)$$

$$\sigma_D = \sqrt{\sum_{i}^{N} (\alpha_i R_i \sigma_i * / R_i *)^2} \qquad (7)$$

where, σ_D is the dose error, σ_i * is the standard deviation of measured data R_i *. The dose and its deviation for the D_2O-75-p irradiation was evaluated using Eqs. (6) and (7), respectively. In Table 2, the evaluated doses for all sets of TLD groups were found close to the expected dose of 1.48mSv.

Comparison of several cases of irradiation

The doses of several irradiations as shown in Table 2 with parenthesis were evaluated by Eqs. (6) and (7). The evaluated doses are also shown in Table 2. During dose evaluation, for each irradiation the measured data R_i * and same co-factors of D_2O-75-p irradiation was used. In order to evaluate the neutron dose accurately, the most suitable set of TLD group was selected comparing the evaluated dose to the expected dose of each irradiation. The set (AaBbE) was an example for dose evaluation of N = 5, mentioned in Eqs. (6) and (7). As shown in Table 2, within the errors, the evaluated doses were found to be almost close to the actual irradiated dose for all irradiations, especially closest on N = 3 of 'AaE' group.

Table 2. Evaluated doses for different irradiations (using co-factors for point source)

No. of TLD Groups	Neutron ambient dose equivalent, $H^*(10)$, mSv				
	D_2O-75-p (1.48)	D_2O-75-r (0.93)	Cf-75-p (1.25)	Cf-150-r (1.85)	Am-Be-75-p (0.52)
3 (AaE)	1.45±0.70	0.93±0.16	1.51±0.46	2.16±0.20	0.62±0.08
3 (BbE)	1.80±1.06	0.82±0.27	1.66±0.75	1.49±0.47	0.99±0.13
5 (AaBbE)	1.56±0.82	0.89±0.19	1.56±0.54	1.95±0.24	0.74±0.10
5 (AaCcE)	1.35±0.63	0.96±0.15	1.45±0.41	2.28±0.20	0.55±0.07
7 (AaBbCcE)	1.44±0.73	0.83±0.19	1.54±0.48	2.10±0.29	0.66±0.08

The directional sensitivity of neutrons was determined comparing the evaluated to expected dose for two selected incidental neutrons directions of ‘p’ and ‘r’ in Fig. 2. By normalization to the respective irradiated dose, it was found that the dose was varied 10% for two different irradiations; Cf-75-p and Cf-150-r at of 75 cm and 150 cm distances, respectively.

Conclusion

An instrument for evaluating the neutron ambient dose equivalent was designed and constructed showing the uniform response to wide energy of neutrons and equal sensitivity to neutron coming from any angular direction. Three sets of TLD detectors were placed at three depths of the monitor to get specific responses to low and intermediate energies of neutrons and fast neutrons independently. TLDs were arranged along 12 radial axes at even intervals, corresponding to the apexes of a regular polyhedron with 20 triangular faces to get the isotropic response. The response of the TLDs for each energy bin was calculated using the MCNP5 code. It was found that the monitor was sensitive to measure three different energy groups of neutrons at three depths of the moderator. The dose response of the monitor was adjusted to the dose of the D_2O-moderated ^{252}Cf neutron source. The calculated result showed that the total ambient dose equivalent varied 3% between the ‘p’ and ‘r’ incident directions of the neutrons. It seemed that the monitor has the sensitivity to neutrons of almost isotropic i.e. the designed monitor has a uniform dose response over a wide energy range of neutrons and has equal sensitivity to neutrons coming from any direction.

A study was done to calibrate and examine the performance of dose evaluation of the developed monitor. This was performed by irradiation experiments using three radio-isotopes of different energy spectrums of neutrons at FRS, JAEA. The experimental result was compared to the MCNP calculated values and a good agreement was obtained between them. The neutron ambient dose equivalent was evaluated in accuracy from the readout data of the selected TLDs groups. The evaluated dose seemed close to the expected dose for all irradiations of different energy spectrum of neutrons, neutrons incident directions and irradiation distance between the source and the monitor. It was observed that by using the developed monitor, the neutron ambient dose equivalent could be evaluated with better accuracy compared to the existing equipments at different workplaces.

Acknowledgements

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EFFECT OF GAMMA RAY ON NERICA-1 RICE AND SELECTION OF DESIRABLE MUTANTS

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Abstract

With a view to assess the effect of gamma ray on different seedling and reproductive traits, and selection of desirable mutants in the M_2 generation, seeds of NERICA-1 rice were exposed to 250, 350 and 450 Gy doses of gamma ray from ^{60}Co source of the Institute of Food and Radiation Biology (IFRB), Savar, Dhaka. Immediately after irradiation, the seeds were water soaked overnight and left for sprouting. The sprouted seeds were then sown dose wise along with an un-irradiated seeds (control) following non-replicated design at the Bangladesh Institute of Nuclear Agriculture (BINA) farm, Mymensingh in February 2012. It was observed that germination and plant survival decreased gradually in M_1 generation with the increased radiation doses. Similarly, in the reproductive stage, plant height, number of effective tiller, panicle length, pollen viability, filled grains per panicle, grain yield per plant and 1000-seed weight were also decreased gradually. In this study, 50% reduction of germination and survival percentages occurred at 350-450 Gy doses of gamma ray, while for grain yield, it was only 250 Gy. M_2 generation was grown during February-May 2013 and the highest numbers of 17 mutants were selected from 250 Gy dose of gamma ray based on the higher number of effective tillers, longer panicle length, and higher number of filled but lower number of unfilled grains, higher grain yield and earlier maturity than the control. Moreover, 12 and 5 mutants were also selected from 350 and 450 Gy doses of gamma ray, respectively. Finally, it could be concluded that for future plant breeding applications, 250-350 Gy doses of gamma ray might be used to get maximum genetic variability in NERICA-1 rice.

Key words: Gamma radiation, M_1 and M_2 generations, NERICA-1 rice

Introduction

Mutation breeding is one of the most effective ways of inducing substantial genetic variability in plant species with desirable traits in the new mutant lines (Mei *et al*., 2007). Mutation has been successfully employed in breeding of several food crop varieties, ornamentals and export crops. In plant improvement, the irradiation of seeds may cause genetic variability that enable plant breeders to select new genotypes with improved characteristics; like precocity, salinity tolerance, grain yield and quality (Ashraf *et al*., 2003).

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The use of induced mutation in crop improvement has proven to be an effective approach to improve yield, quality and resistance to biotic and abiotic stresses (Bibi *et al*., 2009). The technique has been successfully utilized by the Bangladesh Institute of Nuclear Agriculture (BINA) and many other reseach Institutes for different crops (Azad *et al.,* 2012; Moseley *et al.,* 2010).

New Rice for Africa (NERICA) is an inter-specific cultivar of rice developed by African Rice Centre (WARDA) in 1996 with a view to attain self-sufficiency in rice production and economic development. The cultivar was developed by crossing between *Oryza glaberrima* and *Oryza sativa* (Dingkuhn *et al.,* 2004). The key features of NERICA rice offered by the parent *Oryza glaberrima* are early maturity (90–110 days), drought tolerance, resistance to rice gall midge, rice yellow mottle virus and blast disease, and profuse early vegetative growth (Somado *et al.,* 2008). On the other hand, features offered by the parent *Oryza sativa* are non-shattering, secondary branches on panicles, responsiveness to low mineral fertilization, higher growth with low uptake of water and upright growth, especially at reproductive stage enabling the plant to support heavy seed heads (WARDA, 2005). However, in Bangladesh condition, NERICA rice varieties are not performing well in terms of yield and stability under both rainfed and irrigated conditions. Besides, the NERICA rice varieties are also showing susceptibility towards major insect-pests and diseases. For this, seeds of NERICA-1 were irradiated with different doses of gamma ray to assess the effective dose for creating adequate genetic variability and selection of desirable mutants in M_2 generation.

Materials and Methods

Seeds of NERICA-1 rice were exposed to 250, 350 and 450 Gy doses of gamma ray from ^{60}Co source of the Institute of Food and Radiation Biology (IFRB), Bangladesh Atomic Energy Commission (BAEC), Savar, Dhaka. After irradiation, the seeds were water soaked overnight and left for sprouting. The sprouted seeds were then sown dose wise at 20 cm distances within rows of 20 cm apart in plots of 5.0 m × 2.0 m size along with an un-irradiated seeds (control) at BINA farm, Mymensingh in February 2012. The experiment was done in a non-replicated design.

Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MoP) were applied at the rate of 172, 136 and 66 kg ha^{-1}, respectively for both the generations. TSP and MoP were applied during the final land preparation but urea was applied in three equal splits, after 7, 22 and 35 days of sowing. The M_1 plants that survived up to maturity were harvested and kept separately to grow in M_2 generation. In M_2 generation, seedlings were raised from the seeds of the survived plants in M_1 generation during December-January 2013 and transplanted in February 2013 at BINA farm, Mymensingh in separate plots dose wise under rainfed condition. A unit plot comprised of a 3.0 m row. Seedlings were spaced at 15 cm within rows of 20 cm apart. Necessary intercultural operations were performed in proper time to ensure proper growth of the crop.

In M_1 generation, data were taken in respect of germination percent and plant survival during seedling stage, while plant height, panicle length, pollen sterility, filled and unfilled grains panicle^{-1}, yield hill^{-1} and 1000-grain weight were taken during reproductive stage. Pollen viability testing was done using 1% potassium iodide (KI) solution during 50% flowering in M_1 generation. Five panicles were harvested randomly from five plants in each dose. The collected pollens from the five panicles were then placed on a glass slide and mixed with 1% KI solution. The glass slide was then examined with a microscope. The stained pollens were viable and the unstained were sterile.

In M_2 generation, data were taken on plant height, panicle length, number of effective tillers hill^{-1}, filled and unfilled grains panicle^{-1}, days to maturity and yield from the selected plants only. Selections of mutants in M_2 generation were done based on higher number of effective tillers, longer panicle length, higher number of filled but lower number of unfilled grains, higher grain yield and early maturity than the control. Finally, the collected data were analyzed statistically and results were produced.

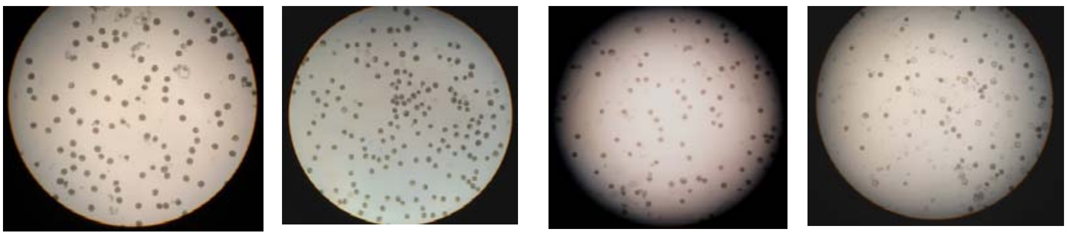
Results and Discussion

Germination and survival percentages decreased gradually with the increase of gamma radiation doses (Table. 1). It is very common in mutation breeding that with increased doses of radiation, gradual decrease in germination and survival occurs in rice and other crops (Ashraf *et al*., 2003; Mohamad *et al.,* 2006; Manneh *et al.,* 2007). Likewise; plant height, panicle length, number of filled grains, yield and thousand grain weight decreased gradually with the increase of radiation doses (Table 1). In contrast, pollen sterility (Fig. 1) and number of unfilled grains increased gradually with the increase of the doses of gamma ray.

These results are in conformity with that of Kiong *et al*. (2008) who reported that gamma ray induced reduction in germination and survival in African rice (*Oryza glaberrima*). Melki and Marouani (2009) observed that treating seeds with high rates of gamma radiation reduced germination with a corresponding decline in growth of plants in cereals. Harding *et al.* (2012) reported that germination percentage and effective tiller number decreased after gamma irradiation in rice. Shah *et al*. (2008) found that the frequency of physiological injury and mortality increased with the increase of mutagen doses. Shehzad *et al*. (2011) found a reduction in plant height up to 40 cm in the mutant Giza 171-M_6 compared to control while working with induced mutation using gamma ray. Siddiqui and Sanjeeva (2010) found that number of panicle bearing plant decreased with the increased radiation dose in two varieties of Basmoti rice in M_1 generation. Kumar *et al*. (2013) reported that pollen fertility decreased with the increase of gamma radiation dose in an approximately linear fashion. In this study, 50% reduction of germination and survival percentage occurred at 350-450 Gy doses of gamma ray (Table 1). In contrast, for grain yield it was only 250 Gy dose of gamma ray.

Table 1. Effect of Gamma radiation on different plant parameters in M_1 generation

Gamma ray doses (Gy)	Germination (%)	Survival (%)	Plant height (cm)	Panicle length (cm)	Pollen viability (%)	Filled grains $panicle^{-1}$ (no.)	Unfilled grains $panicle^{-1}$ (no.)	Grain yield $plant^{-1}$ (g)	1000 grain weight (g)
Control	94.33	76.6	92.40	25.4	84.77	80.17	19.83	15.86	29.89
250	83.8	67.2	84.60	24.44	72.03	67.44	32.56	6.75	26.55
350	62.41	49.8	82.16	23.9	60.12	62.5	37.5	4.82	23.88
450	46.83	34.76	76.47	22.6	48.75	57.98	42.02	3.15	21.2
Mean	71.84	57.09	83.91	24.09	66.42	67.02	32.98	7.65	25.38
SE(±)	2.31	2.15	1.29	0.54	7.75	2.67	1.37	1.19	0.91



Control **250 Gy** **350 Gy** **450 Gy**

Fig. 1 Pollen viability of M_1 mutants of NERICA-1 rice

Selection of mutants in M_2 generation

Robbelen (1991) suggested that mutation characters are usually expressed largely in M_2 generation and mutant phenotypes can only be selected in this generation. So, in the present study in M_2 generation, 17 mutants were selected from

250 Gy (Table 2), 12 mutants from 350 Gy (Table 3) and only 5 mutants from 450 Gy (Table 4) doses based on longer panicle length, more effective tiller and filled grains but less unfilled grains, higher seed yield and earlier maturity than the control. It was evident that the highest number of desirable mutants were selected from 250 Gy dose of gamma ray. This meant that 250 Gy dose of gamma ray was more efficient in inducing desirable mutants in NERICA-1 rice followed by 350 Gy.

Table 2. Grain yield and yield attributes of 17 selected M_2 mutants of NERICA-1 rice derived from 250 Gy gamma ray

Mutants	Plant height (cm)	Panicle length (cm)	Effective tillers hill^{-1}	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	Grain yield plant^{-1} (g)	Days to maturity
RM-N_1-250-15	91	26	9	165	23	23.8	98
RM-N_1-250-16	92	26	7	169	18	21.8	103
RM-N_1-250-24	90	26	6	165	26	18.5	99
RM-N_1-250-28	84	26	5	147	23	19.2	103
RM-N_1-250-29	82	27	5	141	26	22.5	102
RM-N_1-250-37	87	26	6	162	26	19.7	104
RM-N_1-250-38	88	27	6	154	28	17.2	104
RM-N_1-250-47	91	28	5	140	29	19.9	99
RM-N_1-250-49	92	26	8	142	24	24.1	103
RM-N_1-250-54	87	26	7	160	27	21.3	101
RM-N_1-250-56	89	27	6	142	26	19.5	104
RM-N_1-250-78	92	27	6	156	25	22.9	102
RM-N_1-250-80	86	28	6	170	23	17.9	99
RM-N_1-250-82	84	26	6	165	24	20.3	100
RM-N_1-250-84	85	26	6	148	28	18.5	103
RM-N_1-250-106	89	26	5	148	23	17.9	104
RM-N_1-250-111	91	26	6	159	26	23.4	98
Control	92.8	25.5	4.5	139	35.8	16.45	106
Range	82- 92	21-28	5-9	140-170	18-29	17.2-24.1	98-104
Mean	88.24	26.18	6.18	154.88	25.00	20.49	101.53
SE(±)	0.77	0.17	0.26	2.52	0.64	0.54	0.54

Table 3. Grain yield and yield attributes of 17 selected M_2 mutants derived from 350 Gy gamma ray irradiated population of NERICA-1 rice

Mutants	Plant height (cm)	Panicle length (cm)	Effective tiller (no.)	Filled grains $panicle^{-1}$ (no.)	Unfilled grains $panicle^{-1}$ (no.)	Grain yield $plant^{-1}$ (g)	Days to maturity
RM-N_1-350-10	91	26	6	146	33	16.5	105
RM-N_1-350-11	89	28	8	154	35	24.5	101
RM-N_1-350-12	92	27	7	149	31	19	101
RM-N_1-350-16	89	27	8	150	31	20.8	100
RM-N_1-350-26	90	27	7	156	35	25	104
RM-N_1-350-33	92	26	8	148	32	18.9	105
RM-N_1-350-51	92	28	6	148	20	17.8	105
RM-N_1-350-52	92	27	7	157	27	22.6	102
RM-N_1-350-53	90	28	5	151	19	24.1	100
RM-N_1-350-58	91	28	7	147	24	20.2	103
RM-N_1-350-65	91	27	6	146	34	16.7	100
RM-N_1-350-66	89	28	7	145	32	16.9	104
Control	92.8	25.5	4.5	139	35.8	16.45	106
Mean	90.67	27.25	6.83	149.75	29.42	20.25	102.50
SE(±)	0.36	0.22	0.27	1.15	1.62	0.91	0.60

Table 4. Grain yield and yield attributes of 5 selected M_2 mutants derived from 450 Gy gamma ray irradiated population of NERICA-1 rice

Mutants	Plant height (cm)	Panicle length (cm)	Effective tillers $hill^{-1}$ (no.)	Filled grains $panicle^{-1}$ (no.)	Unfilled grains $panicle^{-1}$ (no.)	Grain yield $plant^{-1}$ (g)	Days to maturity
RM-N_1-450-1	91	26	6	145	26	18.8	105
RM-N_1-450-2	90	27	7	149	33	19.4	102
RM-N_1-450-4	89	27	5	142	31	17.5	103
RM-N_1-450-5	92	26	6	163	25	19.8	102
RM-N_1-450-8	92	28	7	143	26	17.9	105
Control	92.8	25.5	4.5	139	35.8	16.45	106
Mean	90.8	26.8	6.2	148.4	28.2	18.68	103.4
SE (±)	0.58	0.38	0.38	3.84	1.59	0.43	0.68

Conclusion

Gamma ray is a potential mutagen to create genetic variability and provides a greater scope for selection of desirable mutants in succeeding generations. Here, gamma ray showed significant negative effects on germination, plant survival, plant height, panicle length, pollen viability, number of filled grains, grain yield and thousand grain weight with an increased dose of gamma ray in M_1 generation. In this study, 50% reduction of germination and survival percentages occurred at 350-450 Gy doses of gamma ray. In contrast, for grain yield in M_2 generation, greater genetic variability was found with 250 Gy followed by 350 Gy. Finally, it could be concluded that for future plant breeding applications, 250-350 Gy doses of gamma ray might be used to get maximum genetic variability in NERICA-1 rice.

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PROMISING SOYBEAN LINES: EVALUATION AND SELECTION THROUGH MULTI-LOCATION YIELD TRIAL

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Abstract

A field experiment was conducted during January to May 2013 to evaluate the performance of three selected promising soybean lines along with two check varieties. The observations were done in respect of days to maturity, morphological characters, yield attributes and seed yield at Mymensingh, Rangpur, Magura, Chandpur and Noakhali. Significant variations were observed among the genotypes for all the traits, both at individual location and combined over locations. Among the five genotypes, lines BAU-S/70 and AVRDC-73 produced taller plants (67 cm and 70 cm, respectively), while two check varieties BARI Soybean-6 and Binasoybean-1 produced shorter plants (47 cm and 53 cm, respectively). The line BAU-S/70 produced the highest number (68) and BARI Soybean-6 produced the lowest number (53) of pods plant^{-1}. Again, BAU-S/70 produced the higher number of branches and pods plant^{-1} along with higher 100-seed weight. BAU-S/70 produced the highest seed yield (2608 kg ha^{-1}) followed by AVRDC-78 (2567 kg ha^{-1}) while BARI Soybean-6 produced the lowest seed yield (2177 kg ha^{-1}). Because of higher number of branches, pods plant^{-1}, seed pod^{-1} and higher seed yield potential, the genotypes BAU-S/70 and AVRDC-78 could be selected for further trials, both at research station and farmers' field to register as varieties.

Key words: Evaluation, Selection, Soybean germplasm, Yield trials

Introduction

Soybean *(Glycine max* (L.) Merr.) has a high value in agriculture as a good source of protein and vegetable oil. As a legume crop, it improves soil fertility through fixing nitrogen. In Bangladesh, soybean is mostly used as poultry feed and for making some nutritious food dishes and confectionary items (Mondal and Wahhab, 2001; Rahman, 2003). It is also used for animal feed and human foods (Carter *et al*., 2004). Soybean, one of the nature's most versatile crop, is increasingly becoming an important food and cash crop in the tropics due to its high protein content (40%), moderate oil content (20%) and adaptability to various growing environments (Anonymous, 2004; Wilcox, 2004; McKevith, 2005; Golbitz, 2007). In Bangladesh, rapid increase of population together with gradual reduction of cultivable land has posed greater challenges to human health. As a result, the present diet pattern in Bangladesh is highly imbalanced with surplus consumption of cereals and deficit consumption of both pulse and oils (Rahman, 2001).

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In this situation, soybean can be an excellent source of balance diet to the Bangladeshi poor people to meet the deficiencies of proteins, fat, carbohydrates, vitamins, minerals and salts. Despite suitable climatic and edaphic conditions of Bangladesh, soybean occupies only 55,000 hectares (MoA, 2010). The average yield of soybean in the world is about 3.0 t ha^{-1} while it is only 1.64 t ha^{-1} in Bangladesh (SAIC, 2007).

Collection of germplasm is the critical first step in initiating any crop breeding programme and an excellent source of economically useful plant characters in forthcoming new varieties. Collected germplasm can also be a good source of new varieties for direct utilization for cultivation (Singh, 2009; Malek *et al*., 2013). The variation in yield and yield contributing characters and other agronomic characteristics of soybean genotypes have been found to increase or decrease when grown under different climatic and soil conditions (Whigham, 1975). For selecting high yielding soybean varieties, attempts were taken to evaluate the performance of three previously selected promising soybean lines from collected germplasm in comparison with two check varieties in respect of maturity period, morphological characters, yield attributes and seed yield at five different locations of Bangladesh.

Materials and Methods

Plant materials and experimental site

Three promising soybean lines (BAU-S/70, AVRDC-73 and AVRDC-78) and two check varieties (Binasoybean-1 and BARI Soybean-6) were used as the experimental materials. The experiment was carried out at the experimental field of Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, BINA sub-station farms at Rangpur and Magura, and farmers' field at Chandpur and Noakhali districts during January to May 2013.

Experimental design, setting the experiment and intercultural operations

The experiment was laid out in a randomized complete block design with three replications. Plant to plant distance was maintained 7-10 cm in a row while row to row distance was 30 cm. Unit plot size was 20 m^2 (5 m × 4 m). Seeds were sown within first week of January 2013. Triple super phosphate, muriate of potash and gypsum were used as basal dose @ 75, 50 and 50 kg ha^{-1}, respectively during final land preparation. *Rhizobium* inoculum for soybean was used @ 25 g kg^{-1} seeds. Intercultural operations; like weeding, thinning, application of pesticides, etc. were done for proper growth and development of plants in each plot when necessary. Harvesting was done depending upon maturity of the plants in each plot.

Data collection and statistical analysis

Data on various characters, such as; plant height, number of branches plant^{-1}, days to maturity, number of seeds pod^{-1}, 100-seed weight and seed yield were taken from 10 randomly selected plants of each plot. Maturity period was counted when the plant and pods of each plot turned into yellowish brown colour and all the leaves shed. Seed yield of each plot was taken from the eight middle rows avoiding border effects and plot seed yield was converted into kg ha^{-1}. List of all the traits under study and their description of measurement are presented in Table 1. Appropriate statistical analyses were performed with the mean data of each character. Mean differences of different parameters were tested by Duncan`s Multiple Range Test (Gomez and Gomez, 1984).

Table 1. List of seven different traits and their description of measurement

Serial no.	Traits	Methods of measurement
1	Days to maturity	The number of days from sowing to approximately 90% pod turned into brownish colour
2	Plant height (cm)	The height from the base of the plant to the tip of last leaf
3	Branches plant^{-1} (no.)	Total number of pod bearing primary branches in a plant
4	Pods plant^{-1} (no.)	Total number of pods with seed in a plant
5	Seeds pod^{-1} (no.)	Total number of seeds in a pod
6	100-seed weight (g)	Randomly counted one hundred seeds and then weighed
7	Seed yield (kg ha^{-1})	Weighing the seeds produced in a plot and then converted into kg ha^{-1}

Results and Discussion

Mean values for different characters of five individual locations and combined locations of the trial are presented in Table 2 and Table 3, respectively. Results showed that most of the characters showed significant variations both in individual location and combined over locations. In soybean genotypes, significant variations were also reported by other researchers for various morphological traits (Gohil *et al*., 2006; Tavaud-Pirra *et al*., 2009; Ojo *et al*., 2012; Malek *et al*., 2013).

Two lines, AVRDC-73 and BAU-S/70 produced taller plants, while BARI Soybean-6 and Binasoybean-1 produced comparatively shorter plants, both in individual location and combined over locations. In Mymensingh and Rangpur, AVRDC-73 and BAU-S/70 produced significantly taller plants than other genotypes. On an average, AVRDC-73 produced the tallest plant (70 cm) which was closely and insignificantly followed by BAU-S/70 (67 cm). Two check varieties (Binasoybean-1 and BARI Soybean-6) produced shorter plants (52 cm and 53 cm, respectively) and AVRDC-78 had the plant height of 56 cm (Table 3). In location means, the tallest plants were produced in Rangpur and Magura, and shortest plants were produced in Mymensingh.

Table 2. Mean performance of soybean lines along with check varieties for different quantitative characters

Soybean lines/check varieties	Plant height (cm)	Days to maturity	Branches plant^{-1} (no.)	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	100-seed weight (g)	Seed yield (kg ha^{-1})
Mymensingh							
BAU-S/70	66a	115ab	3.5ab	66 a	2.0^{NS}	14.2 a	2737a
AVRDC-73	67a	117a	2.8b	62 a	2.0	13.1 b	2522ab
AVRDC-78	43b	112b	4.3a	53 b	2.1	13.o b	2547ab
Binasoybean-1	41b	112b	3.7ab	53 b	1.8	13.2 b	2683a
BARI Soybean-6	43b	112b	3.5ab	47 b	1.9	12.3 c	2290b
Rangpur							
BAU-S/70	76a	112b	1.8a	74a	2.3a	14.2b	2605a
AVRDC-73	74a	115a	2.2a	67a	2.2ab	13.2d	2474ab
AVRDC-78	62b	114ab	2.2a	65ab	2.0b	14.8a	2434ab
Binasoybean-1	55b	112b	1.3b	52b	2.0b	12.9e	2567ab
BARI Soybean-6	59b	112b	1.9a	51b	2.0b	13.9c	2393b
Magura							
BAU-S/70	66b	110c	0.8b	49a	2.1^{NS}	14.0a	1881^{NS}
AVRDC-73	78a	112bc	1.5a	42a	2.1	13.3b	1878
AVRDC-78	62bc	115b	1.4a	42a	2.0	12.9c	1700
Binasoybean-1	58bc	120a	1.1a	44a	2.1	13.0c	1720
BARI Soybean-6	55c	115b	1.8a	38b	1.8	13.1bc	1617
Chandpur							
BAU-S/70	63^{NS}	112b	3.9a	77a	2.0^{NS}	14.0b	3145a
AVRDC-73	62	113ab	2.0bc	67b	2.1	13.2c	3059a
AVRDC-78	55	115a	2.2bc	57c	2.1	14.9a	2829ab
Binasoybean-1	50	115a	2.7ab	53c	2.1	12.8d	3077a
BARI Soybean-6	52	112b	1.6c	43d	1.9	13.4c	2483b
Noakhali							
BAU-S/70	63ab	112b	3.9ab	74ab	2.0a	14.1b	2671ab
AVRDC-73	68a	115a	5.1a	83a	1.7b	13.2c	2900a
AVRDC-78	56ab	115a	3.3b	62ab	1.7b	14.9a	2239c
Binasoybean-1	60ab	118a	3.3b	57b	1.9ab	13.2c	2296bc
BARI Soybean-6	48b	115a	3.3b	57b	1.9ab	13.2c	2100c

In a column, means followed by common letter(s) do not differ significantly at p = 0.05 by DMRT.

Number of pods plant^{-1} showed significant differences in all the individual location and combined over locations. In all the locations, BAU-S/70 and AVRDC-73 produced significantly higher number of pods plant^{-1}. On an average, BAU-S/70 produced the highest number of pods plant^{-1} (68) closely and insignificantly followed by AVRDC-73 (64 pods plant^{-1}), while AVRDC-78, Binasoybean-1 and BARI Soybean-6 produced 56, 53 and 47 pods plant^{-1}, respectively (Table 3). It was observed that soybean genotypes, those produced higher number of pods plant^{-1} also produced higher seed yield. Chettri *et al.* (2003) also showed that number of pods plant^{-1} influenced positively on seed yield in soybean.

Table 3. Combined means of soybean lines and checks and location means for different quantitative characters

Soybean lines/check varieties	Plant height (cm)	Days to maturity	Branches plant^{-1} (no.)	Pods plant^{-1} (no.)	Seeds pod^{-1} (no.)	100-seed weight (g)	Seed yield (kg ha^{-1})
Combined means over five locations							
BAU-S/70	67ab	112^{NS}	3.0^{NS}	68a	2. 0^{NS}	14.1a	2608a
AVRDC-73	70a	114	3.1	64ab	2.0	13.2c	2567a
AVRDC-78	56bc	114	2.9	56bc	2.0	13.7b	2350ab
Binasoybean-1	53c	115	3.0	53bc	1.9	12.9d	2463ab
BARI Soybean-6	52c	113	2.1	47c	1.9	13.2c	2177b
Location means							
Mymensingh	51c	114^{NS}	3.6a	56c	2.0b	13.2d	2556b
Rangpur	65a	113	1.9c	62b	2.1a	13.8a	2496b
Magura	64a	115	1.3d	43d	2.0b	13.3c	1759c
Chandpur	56b	113	2.5b	60b	2.0b	13.6b	2919a
Noakhali	59b	113	3.8a	67a	1.8c	13.6b	2436b

In a column, means followed by common letter(s) do not differ significantly at p = 0.05 DMRT.

Number of seeds pod^{-1} differed significantly in Rangpur and Noakhali, and its location means also differed significantly. In Rangpur, BAU-S/70 had the highest number of seeds pod^{-1} (2.3) which was closely followed by AVRDC-73 with 2.2 seeds pod^{-1} and other three genotypes had 2.0 seeds pod^{-1}. In Noakhali, BAU-S/70 also produced the highest number of seeds pod^{-1} (2.0) followed by Binasoybean-1 and BARI Soybean-6 producing the same seeds pod^{-1} (1.9 seeds pod^{-1}) (Table 2). Combined means showed insignificant difference for the number of seeds pod^{-1} and it ranged from 1.9 to 2.0 (Table 3). These results are in agreement with the results of Nimbalkar and Gujar (2000). In location means, the highest number of seeds pod^{-1} (2.1) was produced in Rangpur, while the lowest was produced in Noakhali.

The highest weight of 100 seeds was recorded in BAU-S/70 both in Mymensingh and Magura, while it was observed the highest in AVRDC-78 for other three locations. On an average, BAU-S/70 showed the highest 100-seed weight (14.1 g) followed by AVRDC-78 (13.7 g) (Table 2).

Significant variations were observed for days to maturity in individual location. But combined means over locations showed insignificant difference. In Mymensingh, AVRDC-73 required the longest maturity period (117 days) followed by BAU-S/70, while each of AVRDC-78, Binasoybean-1 and BARI Soybean-6 required 112 days to mature. In Magura, Binasoybean-1 required the longest maturity period (120 days) while BAU-S/70 required the shortest (110 days) (Table 2). Combined means over locations for days to maturity ranged from 112 days for BAU-S/70 to 115 days for Binasoybean-1 (Table 3). Location means showed insignificant difference.

Mean seed yield differed significantly for both in individual location and combined over locations, and its location means also differed significantly (Table 2 and 3). Except Noakhali, in other locations, BAU-S/70 produced the highest seed yield and mean seed yield of BAU-S/70 was also the highest. In Mymensingh, BAU-S/70 produced the highest seed yield of 2737 kg ha^{-1}, which was closely and insignificantly followed by Binasoybean-1 (2683 kg ha^{-1}), AVRDC-78 (2547 kg ha^{-1}) and AVRDC-73 (2522 kg ha^{-1}). In Rangpur, BAU-S/70 produced the highest seed yield of 2605 kg ha^{-1}, which was closely and insignificantly followed by Binasoybean-1 (2567 kg ha^{-1}), AVRDC-73 (2474 kg ha^{-1}) and AVRDC-78 (2434 kg ha^{-1}) (Table 2). Combined means over the five locations showed that BAU-S/70 produced the highest seed yield of 2608 kg ha^{-1}, which was insignificantly followed by AVRDC-73 (2567 kg ha^{-1}), Binasoybean-1 (2463 kg ha^{-1}) and AVRDC-78 (2350 kg ha^{-1}). BARI Soybean-6 produced the lowest seed yield of 2177 kg ha^{-1} (Table 3 and Fig. 1).

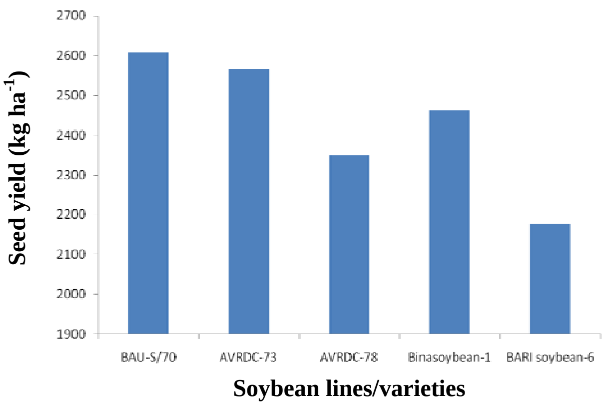

Fig. 1. Combined mean seed yield of five soybean genotypes over five locations

From the results, it was observed that all the high yielding germplasms performed better or above average for most of the morphological characters and yield attributes. Genotypic variability for different morphological and yield contributing characters, and seed yield among soybean genotypes was also reported earlier by other researchers (Bangar *et al*., 2003; Karad *et al.*, 2005; Malik *et al.*, 2006; Aditya *et al.*, 2011; Malek *et al*., 2013).

In the present study, variations observed in seed yield and yield attributes among the soybean genotypes are under genetic control. Variations were also observed for seed yield and yield attributes among the soybean genotypes within locations which may be attributed by the prevailing environmental factors.

Conclusion

From the present study, it might be concluded that over the five locations, BAU-S/70 performed the best followed by AVRDC-78 regarding seed yield and yield contributing characters. Results also indicated that these two lines could be registered as high yielding soybean varieties for commercial cultivation in Bangladesh.

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EFFECT OF DIFFERENT DOSES OF ZINC ON YIELD AND YIELD CONTRIBUTING CHARACTERS OF CHICKPEA CULTIVARS

M. M. Islam

Abstract

A field experiment was conducted at farmer's field in Rajshahi (Godagari) during November 2007 to April 2008 with the objective to find out the effect of zinc on the yield and yield contributing characters of three chickpea genotypes. Two set of treatments were imposed as; (A) cultivar: 3 (Binasola-4, Binasola-3 and Hyprosola) and (B) doses of zinc: 5 (control, 1.5, 2.0, 2.5, and 3.0 kg ha^{-1}). The application of 1.5, 2.0 and 2.5 kg ha^{-1} of Zn fertilizer gave significantly higher seed yield (2.24, 2.48 and 2.29 t ha^{-1}, respectively) over control. On the other hand, seed yield decreased to 2.15 t ha^{-1} by the application of 3.0 kg ha^{-1} of Zn fertilizer. Yield increased at 1.5, 2.0 and 2.5 kg ha^{-1} of Zn were 9.26%, 20.97% and 11.70%, respectively over control. Thus, the results indicated that application of Zn at 1.50-2.0 kg ha^{-1} in chickpea were better for achieving higher seed yield for all the tested varieties.

Key words: Chickpea cultivar, Yield, Zinc fertilizer

Introduction

Among the micronutrients, Zn deficiency is perhaps the most widespread (Roy *et al*., 2006; Ahlawat *et al*., 2007) and common among chickpea growing regions of the world. Chickpea is generally considered sensitive to Zn deficiency (Khan, 1998), although there are differences in sensitivity to Zn deficiency among varieties (Khan, 1998; Ahlawat *et al*., 2007). A comparison between several crop species has shown that chickpea is more sensitive to Zn deficiency than cereal and oil seeds (Tiwari and Pathak, 1982). The critical Zn concentration in soils vary from 0.48 mg kg^{-1} to 2.5 mg kg^{-1} depending on soil type (Ahlawat *et al*., 2007). Zinc deficiency decreases crop yield and delays crop maturity. Zinc deficiency reduces water use and water use efficiency (Khan *et al*., 2004) and also reduces nodulation and nitrogen fixation (Ahlawat *et al*., 2007), which contributes to decreased crop yield. In neutral to alkaline soils, Zn solubility decreases markedly above pH 6.0-6.5 (Sims, 2000). Zinc uptake is positively correlated with the amount of organic matter and negatively correlated with the phosphorus concentration in the soil (Sillanpaa, 1972; Hamilton *et al*., 1993; Ahlawat *et al*., 2007). Soils that have a higher concentration of sand and a lower amount of organic matter, produce lower crop yields which lead to poor Zn utilization (Singh and Ram, 1996).

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Therefore, an attempt was made to evaluate the effect of zinc fertilizer on the yield and yield contributing characters of chickpea.

Materials and Methods

The field experiment was conducted at farmer's field in Rajshahi (Godagari) during November 2007 to April 2008 with the objective to find out the effect of zinc on the yield and yield contributing characters of chickpea. Two set of treatments were imposed as; (A) cultivars: 3 (Binasola-4, Binasola-3 and Hyprosola) and (B) doses of zinc: 5 (control, 1.5, 2.0, 2.5, and 3.0 kg ha^{-1}). The experiment was laid out in a split plot design with 3 replications. The entire experimental field was divided into three blocks. Each block was divided into three main plots and each main plot was divided into five sub plots. Thus, the total number of plots of the experiment was 45 (3 x 5 x 3). The varieties were placed in the main plots and the fertilizers were placed in the sub plots. The land was opened with a power tiller plough. Subsequent ploughing and cross-ploughing were done with power tiller followed by cleaning and removal of weeds. The land was left as such for a few days for operation and conditioning. The land was again ploughed, laddered and cleaned of remaining stubbles and weeds. After making lay out of the experiment, the land was fertilized @ 20.0, 25.0, 28.0 and 10.0 kg ha^{-1}, as N, P, K and S, respectively. Five doses of zinc were used, such as; control, 1.5, 2.0, 2.5 and 3.0 kg ha^{-1}. The sources of the N, P, K, S and Zn fertilizers were urea, triple super phosphate, muriate of potash, gypsum and zinc sulphate, respectively. The fertilizers were used in the experimental plots following the fertilizer recommendation guide (Anonymous, 2005). All the fertilizers were applied as basal at the time of final land preparation. Seeds were sown on 15 November 2007 @ 40 kg ha^{-1}. Before sowing, seeds were mixed with fungicide (Vitavax 200 @ 2 g kg^{-1} seed). Seeds were sown in furrows by hand maintaining uniformity as much as possible. Line to line distance was maintained as 60 cm. Then the seeds were covered with soil to have a good seed soil contact. All the plant characters were recorded from ten randomly selected plants, except seed yield. Seed and stover yield was collected from the whole plot and converted into t ha^{-1}. Data were compiled and analyzed using MSTAT computer package and the mean values were judged by DMRT (Gomez and Gomez, 1983).

Results and Discussion

Different varieties differed significantly in their characters, such as; plant height, branches $plant^{-1}$, pods $plant^{-1}$, seeds pod^{-1} and 1000-seed weight; and the doses of zinc fertilizer affected all the crop characters. The combined effect of variety and zinc showed significant effect on branches $plant^{-1}$, pods $plant^{-1}$, 1000-seed weight, seed yield and harvest index. Different crop characters of the study were described below.

Plant height

Among the varieties, Hyprosola produced the highest plant height (33.16 cm) (Table 1). Binasola-4 and Binasola-3 produced identical plant height (31.81 cm and 31.86 cm, respectively). Among the doses of zinc fertilizer, 1.5 kg of Zn ha^{-1} produced the highest plant height (33.64 cm). The second highest plant height (32.53 cm) was obtained from 2.0 kg of Zn ha^{-1}. Interaction between cultivars and doses of zinc had no significant effect on plant height (Table 2).

Branches per plant

Binasola-4 and Hyprosola produced the highest number of branches (4.58 and 4.44, respectively) and Binasola-3 produced the lowest (4.18). With different levels of Zn fertilizer, number of branches $plant^{-1}$ increased up to 2.0 kg Zn ha^{-1}. Application of zinc at the rate of 2.5 and 3.0 kg ha^{-1} produced identical branches (3.97 and 3.90, respectively). Higher number of branches were produced by Binasola-4, Binasola-3 and Hyprosola at 2.0 kg of Zn ha^{-1} than other treatment combinations (Table 1). However, the variety Binasola-3 produced the highest number of branches $plant^{-1}$ (5.50) at 2.0 kg ha^{-1} of zinc.

Table 1. Mean effects of different doses of zinc fertilizer on crop characters of chickpea cultivars

Treatments	Plant height (cm)	Branches $plant^{-1}$ (no.)	Pods $plant^{-1}$ (no.)	Seeds pod^{-1} (no.)	1000-seed weight (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Harvest index (%)
Varieties								
Binasola-4	31.81 b	4.58 a	48.21 b	1.58 b	122.62 b	2.22	3.13	41.51
Binasola-3	31.86 b	4.18 b	50.35 a	1.56 b	161.23 a	2.25	3.14	41.75
Hyprosola	33.16 a	4.44 a	50.65 a	1.68 a	102.01 c	2.26	3.14	41.73
$LSD_{0.05}$	0.97	0.25	1.49	.06	2.62	ns	ns	ns
Doses of Zn								
0 kg ha^{-1}	31.8 b	4.06 c	43.60 e	1.49 b	128.00 bc	2.05 e	2.85 d	41.79 b
1.50 kg ha^{-1}	33.64 a	4.70 b	52.87 b	1.57 b	131.27 a	2.24 c	3.26 c	40.75 c
2.0 kg ha^{-1}	32.53 ab	5.39 a	57.04 a	1.89 a	129.59 ab	2.48 a	3.45 a	41.63 b
2.50 kg ha^{-1}	32.17 ab	3.97 c	49.24 c	1.59 b	127.47 bc	2.29 b	3.29 b	41.11 bc
3.0 kg ha^{-1}	31.24 b	3.90 c	45.93 d	1.52 b	126.78 c	2.15 d	2.84 d	43.04 a
$LSD_{0.05}$	1.53	0.31	1.81	0.13	2.10	5.55	3.04	0.77
CV (%)	4.89	5.30	2.76	6.33	1.24	1.88	0.74	1.41

In a column, means followed by common letter(s) do not differ significantly at 5% level by DMRT.

Pods per plant

Binasola-3 and Hyprosola produced the highest number of pods plant^{-1} than Binasola-4 which was statistically identical (Table 1). Among the doses of zinc fertilizer, the highest number of pods plant^{-1} (57.04) was obtained at 2.0 kg of Zn ha^{-1}. Interaction showed that the highest number of pods plant^{-1} was obtained in Hyprosola (59.27) and the second highest in Binasola-3 (58.07) at 2.0 kg ha^{-1} of zinc application (Table 2).

Seeds per pod

The variety Hyprosola produced the highest seeds pod^{-1}, where the other two varieties, Binasola-4 and Binasola-3 produced similar number of seeds pod^{-1}. The highest number of seeds pod^{-1} was obtained by the application of 2.0 kg ha^{-1} of zinc. In control, 1.5, 2.5 and 3.0 kg ha^{-1} of zinc produced also considerable seeds pods^{-1} and this was not statistically different. Interaction effect between variety and zinc showed the highest number of seeds pod^{-1} in Hyprosola at 2.0 kg of Zn ha^{-1}. Other two varieties (Binasola-4 and Binasola-3) also showed higher number of seeds pod^{-1} at the same dose of zinc application (Table 2).

Table 2. Interaction effects of cultivars and different doses of zinc fertilizer 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 (t ha^{-1})	Stover yield (t ha^{-1})	Harvest index (%)
Interaction								
Binasola- 4								
0 kg ha^{-1}	32.27	4.17 b-d	43.67 g	1.47	121.05 de	2.02c	2.85	41.43 c-e
1.50 kg ha^{-1}	32.93	4.50 bc	51.27 de	1.47	127.67 c	2.23 b	3.24	40.74 de
2.0 kg ha^{-1}	30.73	5.33 a	53.80 cd	1.90	123.03 d	2.46 a	3.43	41.85 b-d
2.50 kg ha^{-1}	32.20	4.30 b-d	46.93 fg	1.60	122.47 de	2.29 b	3.29	41.07 de
3.0 kg ha^{-1}	30.93	4.60 b	45.40 fg	1.50	118.93 e	2.10 c	2.85	42.47 bc
Binasola-3								
0 kg ha^{-1}	31.13	3.73 d-f	43.47 g	1.43	158.17 b	2.03 c	2.87	41.44 c-e
1.50 kg ha^{-1}	34.73	4.40 bc	55.27 bc	1.43	161.83 ab	2.23 b	3.26	40.64 e
2.0 kg ha^{-1}	31.67	5.50 a	58.07 ab	1.83	163.73 a	2.47 a	3.46	41.65 b-e
2.50 kg ha^{-1}	32.03	4.40 ef	48.47 ef	1.60	160.13 ab	2.29 b	3.29	41.01 de
3.0 kg ha^{-1}	29.73	3.90 c-e	46.47 fg	1.51	162.30 a	2.23 b	2.84	44.02 a
Hyprosola								
0 kg ha^{-1}	32.00	4.27 b-d	43.67 g	1.57	104.80 f	2.11 c	2.85	42.52 bc
1.50 kg ha^{-1}	33.27	5.20 a	52.07 cd	1.80	104.37 f	2.26 b	3.27	40.87 de
2.0 kg ha^{-1}	35.20	5.33 a	59.27 a	1.93	102.00 fg	2.51 a	3.45	41.40 c-e
2.50 kg ha^{-1}	32.27	4.20 b-d	52.33 cd	1.57	99.80 g	2.31 b	3.29	41.26 de
3.0 kg ha^{-1}	33.07	3.20 f	45.93 fg	1.53	99.10 g	2.11 c	2.83	42.63 b
$LSD_{0.05}$	ns	0.54	3.13	ns	3.64	9.61	ns	0.99
CV (%)	4.89	5.30	2.76	6.33	1.24	1.88	0.74	1.41

In a column, means followed by common letter(s) do not differ significantly at 5% level by DMRT.

1000-seed weight

Mean effect showed that the varieties Binasola-4, Binasola-3 and Hyprosola produced 1000-seed weight of 122.62 g, 161.23 g and 102.01 g, respectively (Table 1). Among the doses of zinc, the highest 1000-seed weight was obtained by applying 2.0 kg ha^{-1} of zinc. The interaction effect of variety and zinc revealed that the largest seed size was produced in Binasola-3 (163.73 g) by applying 2 kg Zn ha^{-1} and the smallest seed size (99.10 g) was produced in Hyprosola by applying 3 kg Zn ha^{-1} (Table 2).

Seed yield

All the varieties under the study produced seed yield ranging from 2.22 to 2.26 kg ha^{-1} and it was statistically insignificant (Table 1). Out of five levels of zinc fertilizers, seed yield increased to 2.48 kg ha^{-1} at 2.0 kg ha^{-1} of zinc application. Higher seed yield at 2.0 kg of Zn ha^{-1} might be due to higher number of pods $plant^{-1}$. Seed yield decreased after 2.0 kg ha^{-1} of zinc application. Interaction effect showed that all the varieties produced higher seed yield at 2.0 kg of Zn ha^{-1} (2.51, 2.47 and 2.46 t ha^{-1} in Hyprosola, Binasola-3 and Binasola-4, respectively). Application of 1.5 kg and 2.5 kg of Zn ha^{-1} produced the second highest yield in all the varieties. The lowest seed yield was recorded in Binasola-4 in control (Table 2).

Stover yield

Stover yield under the study produced similar and insignificant in all the varieties (Table 1). Among the different zinc doses, the highest and the second highest stover yields were produced at 2.0 and 2.5 kg ha^{-1} of zinc, respectively. The interaction effect between varieties and doses of zinc showed higher but insignificant stover yield at 1.5 to 2.50 kg ha^{-1} of zinc application in all the varieties (Table 2).

Harvest index

All the varieties under the study produced similar harvest index which was statistically insignificant (Table 1). Considering the effect of zinc, the highest harvest index was obtained at 3.0 kg of Zn ha^{-1} (43%) and the lowest was obtained at 1.5 kg of Zn ha^{-1} (40%). The interaction effect showed the range of higher harvest index (42 to 44%) at 3.0 kg of Zn ha^{-1}application in all the varieties.

The results suggested that application of 1.5, 2.0 and 2.5 kg ha^{-1} of Zn produced significantly higher seed yield (2.24, 2.48 and 2.29 t ha^{-1}, respectively) over control and 3.0 kg of Zn ha^{-1} produced the seed yield of 2.15 t ha^{-1}. The yield increased over control at 1.5, 2.0 and 2.5 kg ha^{-1} of Zn was 9.26%, 20.97% and 11.70%, respectively.

The results revealed that application of Zn at 1.5 to 2.5 kg ha^{-1} in chickpea were the best for achieving higher seed yield. This higher yield might be due to the contribution of higher number of branch $plant^{-1}$, pods $plant^{-1}$ and seeds pod^{-1}. The results were in agreement with the findings of Anil *et al*. (1990). He concluded that Zn at 5 ppm stimulated all the growth parameters and increasing the level of Zn up to 10 ppm had a depressing effect on growth parameters, except the root dry weight. Similar results were obtained by Yadav (1994) for cowpea. He also reported that Zn was required for the production of indole acetic acid which was important for nodulation in legumes (Skoog, 1940). Price (1966) reported that many enzymatic functions related to Zn were known in micro-organisms including Rhizobium and he suggested that Zn deficiency might affect N-fixation directly.

Conclusion

From the study, it revealed that application of Zn at 1.5 to 2.0 kg ha^{-1} could be the best dose for achieving higher seed yield of chickpea.

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EFFECT OF COLCHICINE ON FRUIT AND SEED DEVELOPMENT IN REGENERATED TEASLE GOURD PLANT

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Abstract

Tissue culture technique was applied for micropropagation of teasle gourd (*Momordica dioica* Roxb.) to achieve seedless fruit applying colchicine on callus. The study included the number of fruits per plant and its size, protein content of flesh and number of seeds fruit^{-1}. Number of fruits per plant from natural, regenerated and colchicine treated regenerated plants were 8.2, 7.4 and 7.0, respectively. Treated regenerated plants produced medium sized (6.6 cm) fruit which was larger than natural (6.1 cm) but smaller than regenerated one (9.1 cm). The seed number of colchicine treated fruit drastically reduced to 14.6, whereas natural and regenerated fruit had 33.2 and 26.6 seeds, respectively. The protein content of flesh varied in natural, regenerated and treated regenerated fruits. Edible flesh of 17 days old regenerated fruit had the maximum 7.08% protein, whereas the treated regenerated flesh resulted 4.62% protein followed by 5.54% in natural fruit flesh. Thirty days old fruit flesh had similar trend of protein content.

Key words: Colchicine, Micropropagation, Seedless fruit, Teasle gourd

Introduction

Teasle gourd belonging to the family cucurbitaceae is one of the popular vegetables cultivated in Bangladesh. Bangladesh is a densely populated country and about 43% of the people under five years old are suffering from malnutrition (Anonymous, 2010). The major cause of malnutrition is lack of knowledge about nutrition. Vegetables are the important source of nutrients of human body and good source of vitamins and minerals. The per capita consumption of vegetable in Bangladesh is only 53 g, which is far behind the daily requirement of 200 g head^{-1} day^{-1} (Haque *et al*., 2009). In comparison to other vegetables, its food value is high. It is rich in carotene, protein, carbohydrate and vitamins (vit C) (Nabi *et al.,* 2002). Among the gourds, it has the highest protein content (3.1%) (Bharathi *et. al*., 2011). As a developing country, Bangladesh has minimum source of animal protein like meat. Recently, the government of Bangladesh circulated to mix vitamin-A with soybean oil (Anonymous, 2012). The rural people of Bangladesh are suffering from vitamin-A,

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which is available in teasle gourd. On the other hand, average yield of teasle gourd is only 1.66 tons acres^{-1} which is very low. Whereas 10-12 tons acres^{-1} of this vegetable may be produced if proper methodology is evolved (Rahman *et al.,* 2004). Several factors are responsible for such a low yield of teasle gourd in Bangladesh. Among this, lack of high yielding varieties is one of them. Hence, development of improved cultivars becomes the top priority to overcome the poor yield level. As a vegetatively propagated dioecious plant, micropropagation will be more suitable method of propagation, which could ensure desired ratio of male and female plants easily. Successful application of plant biotechnology for plant improvement or large scale propagation requires the development of an efficient shoot regeneration system from cultured cells or tissues. Tissue culture techniques are becoming increasingly popular as an alternative means of plant vegetative propagation. The success of many *in vitro* selection and genetic manipulation techniques in higher plants depend on the success of *in vitro* plant regeneration. Quality of fruit of teasle gourd deteriorates due to presence of large number of seeds. It may be possible to reduce seeds in teasle gourd by applying some mutagens during tissue culture. Induction of somaclonal variation through callus culture may also provide some seedless plants. Use of mutagens during tissue culture method may bring heterogenecity, which may be a means of producing seedless teasle gourd. *In vitro* multiplication of elite clones will be an attractive approach in order to meet the requirement of quality propagules at large scale for commercial cultivation. Thus, the present study was undertaken to achieve the following objectives:

i) To induce variations among the germplasms using chemical mutagens; and
ii) To screen the desired plant variants for quality fruits (seedless or reduced seeded fruit) and high yielding plant types.

Meterials and Methods

Fast growing callus was obtained from cotyledon of immature fruit from the teasle gourd. Among hormonal supplements, 1 mgL^{-1} BA was useful. The detailed procedure for explant sterilization, establishment and maintenance of callus and regeneration protocol were described earlier (Karim and Ahmed, 2010). All media were adjusted to pH 5.8 prior to sterilization. Cultures were kept at 24 ± 2°C.

For colchicine experiment, colchicine was dissolved in water for the preparation of 0.05% solution. Colchicine treatment was given for 1, 2, 4 and 8 hours. The flasks containing 20 callus pieces flask^{-1} soaked by the liquid medium. A few calli showed necrosis and early death. After treatment for a varying length of time, surviving calli were washed several times with sterilized distilled water and transferred to solid regeneration medium that contained 1 mgL^{-1}BA.

For another type of treatment, colchicine was mixed with MS medium at 10, 20, 30 and 40 mgL^{-1} for 3, 6 and 9 days. After 3, 6 and 9 days culturing on colchicine supplemented media, the calli were subcultured on MS medium with 1mgL^{-1} BA. Sterilization of colchicine was made by using filter (Pore size 0.22 µ mesh).

Fruits from natural, regenerated and treated regenerated plants were taken for measurement of protein content. One gram of sample (oven dried seed and flesh of fruit) was weighed accurately and taken in digestion flask (Kjeldahl flask). Three to 4 gm of digestion mixture ($CuSO_4$: K_2SO_4 = 1:5) were added to it. Twenty milliliter of concentrated H_2SO_4 was added into the flask. The flask was placed on digestion chamber and boiled until the solution became clear. The flask was cooled slowly and 150 ml distilled water was added to it. Some glass beads and zinc granules were added to avoid bumping. Hundred 1 ml of 40% NaOH solution was poured into the flask very slowly holding the flask about 45^0 angle and immediately the flask was connected to a distillation set. The liberated ammonia was collected in a conical flask which was previously placed under the condenser jet containing 25 ml of 2% boric acid solution and 2-3 drops of mixed indicator (methyl red and methyl blue). At least 125 ml distillate was collected into the conical flask. Frequent bumping of the flask indicated the completion of the distillation. Distillation was titrated with 0.2N HCl. The Calculation is shown as below:

$$\% \text{ Protein} = \% \text{ N} \times 5.5$$

$$\% \text{ N} = \frac{(T_S - T_B) \times \text{normality of acid} \times 0.014}{\text{Wt. of sample (in gm)}} \times 100$$

Here, T_S = Titre value of the sample
T_B = Titre value of the Blank
0.014 = Milliequivalent of nitrogen and
5.5 is a conversion factor

Results were expressed in grams of protein per 100 grams of experimental sample.

Results and Discussion

Length and diameter of edible fruit

Length and diameter of edible fruit varied significantly (Table 1). The maximum length (9.1 cm) of fruit was recorded in regenerated plant and the fruit of natural plant had the minimum length (6.1 cm) which was similar to the treated regenerated plant (6.6 cm). The maximum diameter of fruit was found in natural plant (4.5 cm) (Plate 1). The shape of natural fruit was round but regenerated fruit was cylindrical (Plate 1).

Average fruit weight

Average fruit weight varied significantly among the plants (Table 1). The maximum fruit weight (63.6 g) was recorded in regenerated plant, whereas the fruit weight of treated regenerated plant was minimum (39.2 g). Rasul *et al.* (2004) found that the individual fruit weight varied from 40 to 625 g (wild accession) in 30 teasle gourd accessions.

Table 1. Fruit characters of natural, regenerated and treated regenerated plants

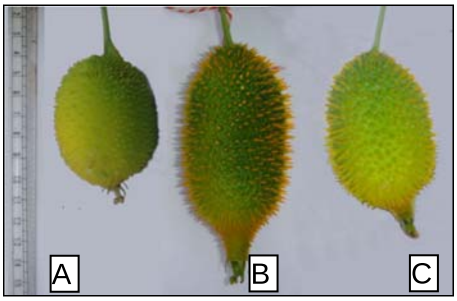
Plant	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)	Seeds fruit^{-1} (no.)	10-seed weight (g)
Natural plant	6.1b±0.2	4.5a±0.2	51.2b±5.8	33.2a±2.4	2.4a±0.5
Regenerated plant	9.1a±0.7	4.3b±0.3	63.6a±6.7	26.6b±3.7	2.5a±0.4
Treated regenerated plant	6.6b±0.7	3.9b±0.1	39.2c±2.5	14.6c±1.7	1.7c±0.3
Level of sig.	***	**	***	***	*

Mean values ± SD for 5 replicates of each plant type. *** $P < 0.001$ (0.1%). ** $P < 0.005$ (0.5%).
In a column, means followed by common letter(s) do not differ significantly at 5% level by DMRT.

Number of seeds fruit^{-1}

The number of seeds fruit^{-1} differed among natural, regenerated and treated regenerated plants (Table 1). The treated regenerated plants produced the minimum number of seeds fruit^{-1} (14.6) whereas the natural plant produced the maximum number of seeds fruit^{-1} (33.2). The fruit from regenerated plant had 26.6 numbers of seed. Among 30 accessions of teasle gourd, 19 accessions produced 16-30 seeds, eight 31-45 seeds and only three (Acc 8, Acc 19 and Acc 20) 46-60 seeds fruit^{-1} (Rasul *et al.,* 2004).

Plate 1. Fruit from different plants (15-days old).



A) Fruit from natural plant
B) Fruit from regenerated plant
c) Fruit from treated regenerated plant

Fresh weight of 10-seed

The maximum weight of 10 seeds (2.5 g) was recorded in fruits from regenerated plants which was similar to natural fruits, whereas the treated regenerated fruits produced minimum weight (1.7 g) of 10 seeds (Table 1). The colour of natural seeds was dark brown while the regenerated seeds was brown (Plate 2). Size of seed is an important factor to be considered for varietal development because large seed is undesirable in case of teasle gourd. Rasul *et al.* (2004) found that the 10-seed weight varied from 1.3 to 16.4 g (wild).

Plate 2. Seed from different types of fruits

A) Seeds from natural fruit, B) Seeds from regenerated fruit, C) Seeds from treated regenerated fruit

Protein content

The protein content of flesh and seed after 17 and 30 days old fruit differed each other in natural, regenerated and treated regenerated plants (Fig. 1). Seventeen days old fruit flesh of regenerated fruit had the maximum (7.08%) protein content whereas the treated regenerated flesh had the minimum (4.62%) protein content followed by natural flesh (5.54%). The seed of natural fruit had the maximum (15.71%) protein content whereas the treated regenerated seed had the minimum (1.54%) protein content.

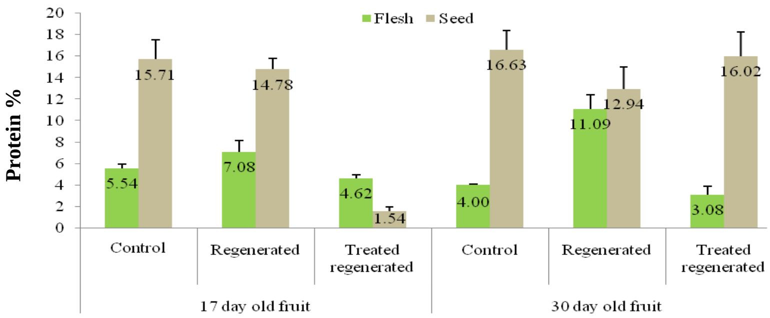


Fig 1. Protein content of flesh and seed of natural, regenerated and treated regenerated fruit of teasle gourd after 17 and 30 days. Vertical bar showing standard deviation.

Thirty days old fruit had similar trend of protein content in flesh. The seeds of natural fruit had the maximum (16.63%) protein content which was similar to the treated regenerated fruit (16.02%), whereas the regenerated seed had the minimum (12.94%) protein content. Bharathi *et al.* (2011) found that teasle gourd contained 3.1% protein which was the highest than from the other gourds.

Conclusion

It was concluded that the highest protein accumulation was found in fruits of regenerated plant and the reduced number of seeds were found by the application of colchicine.

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EFFECT OF CULTIVAR AND PLANTING METHOD ON THE PERFORMANCE OF TRANSPLANT *AMAN* RICE

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Abstract

An experiment was conducted to determine the effect of cultivars and planting methods on the performance of transplant *Aman* rice. Three cultivars viz., Binadhan-4, BRRI dhan40 and BRRI dhan41 and four planting methods viz., direct wet seeding by drum seeder, direct wet seeding by hand, line transplanting and haphazard transplanting method were included as experimental treatments. The experiment was laid out in a randomized complete block design with three replications. The results revealed that cultivar BRRI dhan41 produced the highest grain (4.42 t ha^{-1}) and straw yield (6.33 t ha^{-1}) which were the resultant effect of yield parameters like effective tillers $hill^{-1}$ and number of grains $panicle^{-1}$. The highest grain (4.62 t ha^{-1}) and straw yields (6.31 t ha^{-1}) were produced by the direct wet seeding by drum seeder method. In case of interaction, BRRI dhan41 and direct wet seeding by drum seeder method produced the highest grain yield (4.83 t ha^{-1}). It might be concluded that the cultivar BRRI dhan41 of transplant *Aman* rice could be grown in wet seeding by drum seeder method for higher grain yield.

Key words: Cultivar, Planting method, Rice, Yield

Introduction

Bangladesh is an agricultural country and its agriculture is predominantly rice-based. Rice is grown throughout the year in the country. The area and the production of rice in the country are 11.25 million hectares and 29.75 million tons, respectively (Anonymous, 2008). Food deficit has been increasing in Bangladesh at an alarming rate due to increase in population growth and low yield of food crops achieved per unit area. About 220 hectares of agricultural lands are decreasing per year due to urbanization, industrialization, housing and road construction purposes, etc. So, we have to think how to solve the food problem of the country. Since there is little scope of horizontal expansion of the rice area in the country, attempt should be made to increase the yield per unit area. Therefore, to bring about radical increase in rice production, it is necessary to replace the low yielding traditional cultivars and old production practices by modern cultivars and improved production technology (Anonymous, 1997).

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Cultivar itself is a genetic factor which contributes much in producing yield and yield components of a particular crop; yield components are directly related to a cultivar and its environment where it grows. A rice farmer needs a number of cultivars of rice in a particular season for alternative use for higher yield as well as high economic return. That is why continuous efforts are being taken towards the development of new rice cultivars and their management practices to increase the yield per unit area. The high yielding cultivars have higher yield potentiality compared to the existing local cultivars. Bangladesh Rice Research Institute (BRRI) has released 63 modern cultivars of rice suitable for cultivation in different regions and Bangladesh Institute of Nuclear Agriculture has released 14 modern cultivars of rice. Among these, Binadhan-4, BRRI dhan40 and BRRI dhan41 are suitable for cultivation in *Aman* season. Higher yield could be achieved from these cultivars if appropriate method of planting is used for cultivation.

There are three methods of rice cultivation, namely transplanting, wet seeding and dry seeding (Pandey, 1994). With the advent of improved agricultural machinery coupled with shortage of farm labour, mechanization is becoming inevitable and as such we must strive to take advantage of those. Rice cultivation in Bangladesh is predominantly practiced in transplanting method which involves raising, uprooting and transplanting of seedlings. This is rather a resource and cost intensive method since preparation of seedbed, raising of seedling and transplanting are labour and time intensive operations. Research reports show that labour involvement in these operations consumes nearly one third of the total cost of production of transplant aman rice in Bangladesh.

Direct wet seeding via hand broadcasting has been found to give 10-15 percent increased yield. Direct seeded crop also matures 10-20 days earlier than the transplanted one (Pandiarajan *et al.*, 1999). Despite these advantages, this method has also the difficulties of weeding practice in Bangladesh. However, much of the problems associated with direct wet-seeding by broadcasting are successfully overcoming by the use of drum seeder without deteriorating yield or any other advantages of the technique. Direct wet seeded rice using drum seeder has out yielded the conventional transplanted rice by 15-20 percent both in July-November and November-May seasons (Husain, 2005).

Only two persons are required to sow seeds in one hectare in direct wet seeding by drum seeder compared to about 45 persons requiring for uprooting and transplanting. Seed requirement for direct wet-seeding by drum seeder is only about 25 kg ha^{-1} (if seeded by single thin rows of the drum seeder) which is much lesser than that normally used by the farmers for transplanting; thus, resulting in a saving of one thousand taka per hectare. In addition, the drum seeded rice matures 10-20 days earlier than the transplanted rice of the same cultivar. This reduction in growth period is because crop remains always undisturbed throughout its life cycle or never experiences any uprooting and transplanting shock.

Direct seeded rice has healthy and vigorous growth (Husain, 2005). By using drum seeding method, farmers can get several benefits, such as; higher returns, less labour involvement and less water use compared to the transplanting method. Therfore, the popularity of drum seeding method is increasing day-by-day in Vietnam, Korea and Japan. In the light of the above background, the present study was undertaken to find out the performance of suitable rice cultivar and planting method for *Aman* rice cultivation.

Materials and Methods

The experiment was carried out at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from July to December 2008. The experiment was laid out in a randomized complete block design (RCBD). The experimental treatments consisted of two factors: (a) three cultivars viz., Bianadhan-4, BRRI dhan40 and BRRI dhan41 and (b) four planting methods viz., direct wet seeding by drum seeder, direct wet seeding by hand, line transplanting and haphazard transplanting. The unit plot size was 10 m^2 (4.0 m × 2.5 m) and was separated by 0.5 m wide bund. The blocks were separated by 1.0 m drain. The experimental field was fertilized with 82.95, 20, 35, 10.9 and 3.6 kg ha^{-1} of N P K S Zn, respectively in case of BRRI dhan40 and BRRI dhan41; and 78.34, 24, 32.5, 11.8 and 3.6 kg ha^{-1} of N P K S Zn, respectively in case of Bianadhan-4 as urea, triple super phosphate, muriate of potash, gypsum and zinc sulphate, respectively. All the fertilizers, expect urea were applied at the time of final land preparation. Urea was top dressed in three equal splits at 30, 50 and 70 days after sowing (DAS) in case of direct seedling method; and 20, 40 and 60 days after transplanting (DAT) in case of transplanting method. Sprouted seeds of three cultivars were sown in the well puddled plots by drum seeder in 20 cm apart lines on 21 July 2008. On the other hand, for raising seedlings (for transplanting method) sprouted seeds of the three cultivars were sown in previously prepared nursery beds on the same day. Transplanting was done on 21 August 2008. Two seedlings were transplanted in each hill. Transplanting was done in lines maintaining a spacing of 25 cm × 15 cm and transplanting in haphazard was done without maintaining spacing. Intercultural operations viz., gap filling, weeding, water management and plant protection measures were taken in order to support normal plant growth. The crop of each plot was harvested from 5 m^2 of the central area with sickle at full maturity. The direct seeding crop was matured 15 days earlier than the transplanted rice of the same cultivar. Just prior to harvesting, five hills excluding the border plants and the harvest area of each plot were selected at random and uprooted for collecting data on yield components. The collected data were compiled and tabulated for statistical analysis. Analysis of variance was done with the help of computer package M-STAT. Means were adjudged by Duncans Multiple Range Test (Gomez and Gomez, 1984).

Results and Discussion

Effect of cultivar

All the yield and yield contributing characters of transplant *Aman* rice were significantly influenced by the cultivar, except panicle length and thousand grain weight (Table 1). The tallest plant (121.34 cm) was obtained in BRRI dhan4l and the shortest (117.03 cm) in Bianadhan-4 (Table 1). This might be due to genetic makeup. The maximum number of effective tillers hill^{-1} (16.62) was observed in BRRI dhan4l and minimum (8.44) in Binadhan-4. Effective tiller is the major factor to increase grain yield in cereal production. The highest number of grains panicle^{-1} (150.94) was observed in BRRI dhan4l and the lowest (107.20) in Binadhan-4. Cultivar differences regarding the number of grains panicle^{-1} might be due to the differences in genetic constituents. BRRI dhan4l produced the highest grain yield (4.42 t ha^{-1}) and Bianadhan-4 produced the lowest grain yield (3.64 t ha^{-1}). The highest straw yield (6.33 t ha^{-1}) was also obtained in BRRI dhan41 and the lowest (5.19 t ha^{-1}) in Bianadhan-4. BRRI dhan40 showed the highest harvest index (41.98%) and the lowest (40.08%) was found in BRRI dhan41, which was statistically similar with Bianadhan-4.

Effect of planting method

Planting method exerted a positive effect on plant height, number of effective tillers hill^{-1}, number of grains panicle^{-1}, weight of thousand grains, grain yield, straw yield and harvest index (Table 2). The tallest plant (121.74 cm) was obtained from haphazard transplanting method which was statistically similar to line transplanting (120.92), and the shortest (116.22 cm) was from direct wet seeding by drum seeder method. The lowest plant height might be due to apparently visible dense population. The highest number of effective tillers hill^{-1} (15.21) was obtained from direct wet seeding by drum seeder and the lowest (8.16) was found in haphazard transplanting method. The highest number of grains panicle^{-1} (142.08) was found in direct wet seeding by drum seeder and the lowest (105.51) was observed in haphazard transplanting. Grains panicle^{-1} in direct seeding of sprouted seeds in puddled soils using drum seeder was higher than the transplanted rice which might be the reason for less number of grains panicle^{-1}. These findings are in agreement with the findings of Hussain (2005). The highest grain yield (4.62 t ha^{-1}) was found in direct wet seeding by drum seeder method and the lowest (3.47 t ha^{-1}) in haphazard transplanting method. The highest straw yield (6.31 t ha^{-1}) was found in direct wet seeding by drum seeder method and the lowest (5.13 t ha^{-1}) in haphazard transplanting method. The highest harvest index (42.27%) was obtained from direct wet seeding by drum seeder method. The lowest (40.37%) was from haphazard transplanting method which was statistically similar with direct wet seeding by hand and direct wet seeding by drum seeder.

Interaction effect of cultivar and planting method

The effect of interaction of cultivar and planting method showed significant variation in respect of number of effective tillers hill^{-1}, number of grains panicle^{-1}, grain yield and harvest index (Table 3). The maximum number of effective tillers hill^{-1} (21.33) was in BRRI dhan4l under direct wet seeding by drum seeder and the lowest (7.92) was found in BRRI dhan40 in line transplanting method. The highest number of grains panicle^{-1} (166.88) was found in BRRI dhan4l in direct wet seeding by drum seeder method and the lowest grains panicle^{-1} (85.38) was found in Bianadhan-4 under haphazard transplanting method. The highest grain yield (4.83 t ha^{-1}) was obtained from BRRI dhan4l under direct wet seeding by drum seeder which was statistically similar (4.77 t ha^{-1}) to BRRI dhan40 under direct wet seeding by drum seeder method and the lowest one (3.08 t ha^{-1}) from Bianadhan-4 under haphazard transplanting method. The highest harvest index (42.75%) was observed in the interaction between BRRI dhan40 and direct wet seeding by drum seeder method and the lowest (40.28%) was recorded in the interaction between BRRI dhan41 and direct wet seeding by hand method.

Table 1. Effect of cultivar on different crop characters and yield of transplant *Aman* rice

Cultivars	Plant height (cm)	Effective tillers hill^{-1} (no.)	Panicle length (cm)	Grain panicle^{-1} (no.)	1000 grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
V_1	117.03c	8.45c	24.71	107.20c	26.03	3.64c	5.19c	41.14b
V_2	119.51b	9.96b	24.52	131.41b	26.35	4.15b	5.71b	41.98a
V_3	121.34a	16.62a	25.20	150.94a	26.13	4.42a	6.33a	41.08b
CV (%)	3.99	4.90	4.68	4.68	3.56	3.48	3.40	2.20

V_1 = Binadhan-4, V_2 = BRRI dhan40 and V_3 = BRRI dhan41

In a column, means followed by common letter(s) do not differ significantly at 5% level by DMRT.

From the above discussion, it could be concluded that BRRI dhan41 coupled with direct wet seeding by drum seeder method appeared to be the best in respect of grain yield.

Table 2. Effect of planting method on different crop characters and yield of transplant *Aman* rice

Planting methods	Plant height (cm)	Effective tillers hill^{-1} (no.)	Panicle length (cm)	Grains panicle^{-1} (no.)	1000 grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
M_1	116.22c	15.21a	24.19b	142.08a	25.59	4.62a	6.31a	42.27a
M_2	118.30b	13.35b	24.21b	129.25b	26.60	4.23b	5.95b	41.53a
M_3	120.92a	9.98c	25.15a	117.62c	26.08	3.95c	5.59c	41.43a
M_4	121.74a	8.16d	25.70a	105.51d	26.40	3.47d	5.13d	40.37b
CV (%)	3.99	4.90	4.68	4.68	3.56	3.48	3.40	2.20

M_1 = Direct wet seeding by drum seeder, M_2 = Direct wet seeding by hand
M_3 = Line transplanting and M_4 = Haphazard transplanting
In a column, means followed by common letter(s) do not differ significantly at 5% level by DMRT.

Table 3. Effect of interaction of cultivar and planting method on different crop characters and yield of transplant *Aman* rice

Interaction (V × M)	Plant height (cm)	Effective tillers hill^{-1} (no.)	Panicle length (cm)	Grains panicle^{-1} (no.)	1000 grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
V_1M_1	121.64	11.15ef	23.95	117.01e	25.71	4.26c	5.73	42.61
V_1M_2	119.29	10.32f	24.24	114.73ef	26.35	3.73e	5.54	40.28
V_1M_3	118.58	6.68gh	25.13	111.69f	26.29	3.48f	4.93	41.35
V_1M_4	118.68	5.61h	25.52	85.38g	25.76	3.08g	4.57	40.29
V_2M_1	120.69	13.15d	23.68	142.34c	25.65	4.77ab	6.38	42.75
V_2M_2	118.96	11.92de	23.71	123.16d	26.66	4.30c	5.76	42.72
V_2M_3	120.20	7.92g	25.39	122.75d	26.73	4.03d	5.55	42.06
V_2M_4	120.81	6.86gh	25.30	88.67g	26.35	3.49f	5.16	40.37
V_3M_1	121.40	21.33a	24.93	166.88a	25.41	4.83a	6.82	41.45
V_3M_2	123.94	17.82d	24.69	146.34c	26.79	4.66b	6.56	41.57
V_3M_3	122.78	15.34c	24.92	148.06b	25.23	4.34c	6.28	40.87
V_3M_4	121.16	12.00e	26.27	142.47c	27.10	3.84e	5.65	40.44
CV (%)	3.99	4.90	4.68	4.68	3.56	3.48	3.40	2.20

V_1 = Binadhan-4, V_2 = BRRI dhan40, V_3 = BRRI dhan41; M_1 = Direct wet seeding by drum seeder
M_2 = Direct wet seeding by hand, M_3 = Line transplanting, M_4 = Haphazard transplanting
In a column, means followed by common letter(s) do not differ significantly at 5% level by DMRT.

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REACTION OF ONION MUTANTS TO PURPLE BLOTCH DISEASE UNDER FIELD CONDITION

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Abstract

Field experiments were conducted with 13 mutants of onion (M_4 and M_5) during the rabi season of 2010-11 and 2011-12 at the Bangladesh Institute of Nuclear Agriculture (BINA) farm, Mymensingh and its sub-station at Rangpur in order to find out the reaction of the mutants to purple blotch disease caused by *Alternaria porri* Ellis. The variety BARIpiaj-3 (mother) was used as the check. Seeds were sown in October and seedlings of 50-day old were transplanted in the field in rows. The disease severity of purple blotch was assessed at two months and two and half months, after transplanting when the disease was developed to its maximum extent. The mutant BP_2/75/2 showed moderately susceptible reaction to the disease in both the locations. The rest of the mutants and the check variety showed susceptible to highly susceptible reaction. None of the mutant of onion was found as resistant or moderately resistant against purple blotch disease.

Key words: *Alternaria porri*, Onion, Purple blotch

Introduction

Onion (*Allium cepa* L.) is an important spice crop in Bangladesh. It is grown in about 1.25 lakh hectares of land and its annual production is 8.89 lakh metric tons (Anonymous, 2013). However, the average yield of onion is low as compared to that of other onion producing countries, like China, Japan, the Republic of Korea and the USA (Anonymous, 2009). Disease is considered as an important factor associated with low production of onion. A large number of foliar, root and bulb diseases like purple blotch, stemphylium blight, downy mildew, basal rot attack onion and reduce the yield and quality (Cramer, 2000).

Purple blotch disease is a major problem for onion production and is found all over Bangladesh (Biswas *et al.*, 2009). The disease is caused by a fungus, *Alternaria porri* (Ellis). In field condition, severe infection may cause complete drying of foliage resulting in considerable yield loss. Due to purple blotch disease, a yield loss of 30%

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and seed crop loss of 100% under favorable condition was recorded (Everts and Laey, 1990; Daljeet *et al.,* 1992). The significance of yield loss has turned the management of purple blotch of onion, an important issue in present condition. Management of purple blotch by spraying chemicals has been reported elsewhere (Schwartz and Mohan, 1995; Thamizharasi and Narasimham, 1992; Biswas *et al*., 2009). Chemical management is costly and also not environmental friendly. Development of disease resistant cultivars appears to be a convenient strategy.

Therefore, the present study was undertaken to evaluate the reaction of some mutants of onion to purple blotch under field condition at two agro-ecological zones of Bangladesh.

Materials and Methods

Thirteen mutants of onion derived from seeds of BARI Piaj-2 irradiated with 75, 100 and 125 Gy of Gamma radiation were evaluated against purple blotch under field condition. The variety BARI Piaj-3 was used as the check. The materials were obtained from the Plant Breeding Division of the Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh. The experiments were conducted at BINA farm, Mymensingh and its sub-station at Rangpur during the rabi season of 2010-2011 with M_4 population and 2011-2012 with M_5 population.

The seeds were sown in October 2010 and 2011. Seed bed (3 m × 1.5 m) was prepared in loamy soil. Seeds (5 to 6 kg ha^{-1}) were sown in rows made 10 cm apart from each other. Seeds were covered by giving thin layer of soil. Beds were first irrigated at 3 to 4 days interval and later on at 8 to 10 days interval. Seedlings became ready for transplanting within 45 to 50 days.

Each year 50-day old seedlings were transplanted in the field following Randomized Complete Block Design with 3 replications. The row to row distance was 20 cm and plants were spaced at a distance of 15 cm within the rows. Fertilizers were applied @ Urea: 260 kg, TSP: 200 kg, MP: 150 kg per hectare. Intercultural operations were done as and when required. The disease severity of purple blotch was assessed at two months, and two and half months after transplanting when the disease was developed to its maximum extent. The mutants and the variety were graded following (0 to 5) indexing scale of Sharma (1986) as shown below.

Disease symptom	Score	Disease Reaction
No disease symptom	0	Immune (I)
A few spots towards tip covering 10 percent leaf area	1	Resistant (R)
Several purplish brown patches covering up to 20% of leaf area	2	Moderately resistant (MR)
Several patches with paler outer zone covering up to 40% of leaf area	3	Moderately susceptible (MS)
Leaf streaks covering up to 75% leaf area or breaking of leaves from center	4	Susceptible (S)
Complete drying of leaves or breaking of leaves from center	5	Highly susceptible (HS)

Results and Discussion

In Mymensingh, the mutant BP_2/75/2 was moderately susceptible (Tolerant) to purple blotch of onion (Table 1). Two mutants (BP_2/75/7 and BP_2/125/5) were highly susceptible while the rest of the mutants along with the check variety (BARI Piaj-3) were susceptible (S) to the disease. In Rangpur, only three mutants (BP_2/75/6, BP_2/100/2 and BP_2/125/5) were susceptible (Table 2). The rest of the mutants along with the check variety (BARI Piaj-3) were moderately susceptible (Tolerant). None of the mutant showed highly susceptible (HS) reaction against the disease.

Table 1. Reaction of onion mutants/variety against purple blotch at Mymensingh

Mutants/variety	2010-11		2011-12		Final Grade
	Disease severity (0-5)	Disease reaction	Disease severity (0-5)	Disease reaction	
BP_2/75/2	3	MS	3	MS	MS
BP_2/75/3	4	S	3	MS	S
BP_2/75/5	4	S	3	MS	S
BP_2/75/6	4	S	4	S	S
BP_2/75/7	5	HS	5	HS	HS
BP_2/75/13	4	S	4	S	S
BP_2/100/1	4	S	4	S	S
BP_2/100/2	4	S	4	S	S
BP_2/100/5	4	S	4	S	S
BP_2/100/7	4	S	4	S	S
BP_2/125/5	5	HS	4	S	HS
BARI Piaj-3	3	MS	4	S	S

MS = Moderately susceptible, S = Susceptible, HS = Highly susceptible

Table 2. Reaction of onion mutants/variety against purple blotch at Rangpur

Mutants/variety	2010-11		2011-12		Final grade
	Disease severity (0-5)	Disease reaction	Disease severity (0-5)	Disease reaction	
BP_2/75/2	3	MS	3	MS	MS
BP_2/75/3	3	MS	3	MS	MS
BP_2/75/5	3	MS	3	MS	MS
BP_2/75/6	3	MS	4	S	S
BP_2/75/7	3	MS	3	MS	MS
BP_2/75/13	3	MS	3	MS	MS
BP_2/100/1	3	MS	3	MS	MS
BP_2/100/2	3	MS	4	S	S
BP_2/100/5	3	MS	3	MS	MS
BP_2/100/7	3	MS	3	MS	MS
BP_2/125/5	3	MS	4	S	S
BARI Piaj-3	3	MS	3	MS	MS

MS = Moderately susceptible, S = Susceptible

From the present study none of the mutant of onion was found as resistant or moderately resistant against purple blotch disease. Similar results were obtained by Dhiman *et al.* (1986) where none of the 18 mutants was found as resistant against purple blotch disease. Ambresh and Gowda (2013) reported that out of the 17 lines, only one line was moderately resistant against purple blotch and the rest of the lines were susceptible to highly susceptible to purple blotch.

The mutant BP_2/75/2 showed consistency in disease reaction as it was graded as moderately susceptible (MS) in both the locations. Two mutants (BP_2/75/7 and BP_2/125/5) showed highly susceptible (HS) reaction to the disease in Mymensingh and susceptible (S) reaction in Rangpur. The mutants (BP_2/75/3, BP_2/75/5, BP_2/75/13, BP_2/100/1, BP_2/100/5 and BP_2/100/7) and the check variety (BARI Piaj-3) showed moderately susceptible (MS) reaction in Rangpur but susceptible reaction in Mymensingh. The variation of the susceptibility of the mutants to purple blotch disease might be due to the variation of the environmental factors prevailed at two different locations. The variable environmental factors might have influenced the development of the disease. This was supported by Kareem *et al*. (2012) who reported that infection due to *Alternaria porri* on onion was observed to occur over a temperature range of 15^0 C to 35^0 C, with maximum infection at 25^0 C and the disease development occurred over a range of 75 to 100 per cent relative humidity.

Conclusion

The present investigation indicated that none of the mutant of onion was resistant to purple blotch disease. However, the mutant BP_2/75/2 was moderately susceptible to the disease in both the locations. However, the findings suggested for further research with these mutants of onion at different locations of Bangladesh and at artificial inoculation condition for the confirmation of the result.

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IN VITRO REGENERATION OF POTATO FROM DIFFERENT LEAF SEGMENT AND INTERNODES

R. R. Rajib[1], N. Islam[2], F. H. Shanta[3], M. A. Ullah[4] and K. M. Nasiruddin[5]

Abstract

Two laboratory experiments were conducted with potato cv. Diamant to investigate the effect of growth regulators on callus induction and plantlet regeneration from leaf and internode explants. The first experiment involved different concentrations of 2, 4-D in MS medium which showed significant differences for percent of calli petridish^{-1}, days to callus initiation, callus diameter and weight of calli formed; and 2.5 mg/L 2, 4-D supplemented to MS medium showed highest performance in all cases. The second experiment was conducted using different concentrations of NAA, BAP, IAA and IBA which showed significant differences in number of shoots/vial, shoot length, days to shoot initiation, number of leaves plantlet^{-1}, number of roots shoot^{-1} and root length. In case of shoot regeneration, it could be concluded that the best hormonal combination observed in leaf explant of Diamond variety was 1.5 mg/L NAA + 2.0 mg/L BAP and 2.0 mg/L IAA + 1.0 mg/L IBA.

Key word: Callus, Growth regulator, *In vitro*, MS medium, Potato, Regeneration, 2, 4-D

Introduction

Potato (*Solanum tuberosum* L.) is one of the most economically important annual tuberous vegetable crop. It is the fourth most cultivated food crop in the world after wheat, rice and maize (Solomon and Barker, 2001). It is originated in the Andean Hills of central South America (Keeps, 1979). In Bangladesh, it is mainly used as vegetables, but it is consumed as staple food in more than 40 countries in the world (Anonymous, 2008). Potato produces more food per unit area than cereals. It is cultivated over an area of 345 thousand hectare with an annual production of 5167 thousand tones (Anonymous, 2007). In fact, potato has a great potential to ease out the present situation by minimizing pressure on cereals. There are several reasons for this low productivity; the major one being the non-availability of disease free and certified seed of high yielding potato varieties, resistant to pests and diseases for different ecological zones.

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Yield losses are directly proportional to the intensity of virus infection. Per hectare yield could be easily doubled by the use of healthy and sound seed (Bawden and Kassanis, 1965).

Plant regenerated through callus culture are genetically identical to the source material, free from pathogens; and this process enables producing a huge number of plantlets in a very short period of time (Ehsanpour and Jones, 2000; Fiegert *et al.*, 2000). But the response of explants for callus induction and regeneration are not same in different media concentrations. Tissue culture systems are capable of creating genetic variability and producing plants with novel characters (Akter, 2001). This suggests, tissue culture application could be the viable alternatives in developing new cultivars apart from generating virus free planting stocks and ameliorating heterozygous segregates. This piece of work was undertaken to investigate the *in vitro* callus induction ability and regenerability of potato using 2, 4-D from leaf and internode of explants and the influence of NAA, BAP, IAA and IBA on plantlet regeneration from callus.

Materials and Methods

The research work was carried out in the USDA Biotechnology Laboratory, Department of Biotechnology, Bangladesh Agricultural University, Mymensingh. Potato tubers of variety Diamant were collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur. Disease-free potato tubers were sprouted in the dark condition at room temperature in the Laboratory. The sprouted tubers were then ready to use to obtain leaf and internode explants through *in vitro* development.

In vitro explants of potato (Solanum tuberosum) cv. Diamant were developed using sprouted tubes growing in Murashige and Skoog basal medium. The solid MS medium was prepared having the pH of 5.8 and was sterilized at 121°C for 20 minutes at 15 psi pressure by autoclaving (Murashige and Skoog, 1962). Glassware and other instruments were also sterilized in an autoclave at the same temperature and pressure. Aseptic conditions were maintained throughout the experimental period. The sprouts of potato were rapidly washed in 70% alcohol for 10 minutes and then immersed in 0.1% $HgC1_2$ solution for 15 minutes, and then washed in sterilized water for several times and they were placed in MS medium. Under aseptic condition, one month old microplants were taken out from the test tube and placed on a sterilized petridish. Leaf and internode were cut aseptically. These small pieces of leaf and internode were used as explant. Attempts were made for the induction of organogenesis using leaf and internode explants in MS medium supplemented with 2, 4-D (0.0, 1.5, 2.5, 3.5 mg/L).

The culture was kept in a growth room at 25±2 °C having 1.83 m fluorescent tubes and was illuminated 16 h daily with a light intensity of 1500 lux. Callus initiated after 10-14 days of incubation. After 28-day of inoculation, explants were removed aseptically from the petridish on a sterilized glass plate inside the laminar air flow cabinet and were placed again on freshly prepared sterilized medium containing fixed concentrations of BAP (0.0, 1.0, 2.0 and 3.0 mg/L) and NAA (0.0, 1.0, 1.5 and 2.0 mg/L) for shoot initiation. The subculture vials were then incubated at 22±2^{0}C with 16 h low light intensity. After shoot initiation, more light intensity was given for shoot elongation. When these shoot grew about 2-5 cm in length, rescued aseptically from the cultured vial separated from each other and cultured on another vials with freshly prepared root induction medium IAA (0.0, 1.0, 2.0 and 3.0 mg/L) and IBA (0.0, 0.5, 1.0, and 1.5 mg/L) to induced root. The experiment was laid out in the Completely Randomized Design (CRD) with three replications.

Results and Discussion

Research were conducted to assess the performance of potato variety Diamant on (1) effect of 2, 4-D on *in vitro* callus initiation with different concentrations and (2) potato plantlet regeneration with the supplementation of NAA + BAP and IAA + IBA with different concentrations.

Effect of 2, 4-D on callus initiation

The combined effect of different concentrations of 2, 4-D and explant on the percent of callus/petridish was significant (Table 1). From leaf explant, the highest (80%) and the lowest (23.34%) callus/petridish were observed with the concentration of 2.5 mg/L and 0.0 mg/L, respectively. From internode, the highest callus induction of 70.20% and the lowest of 25% were recorded with the concentration of 1.5 mg/L and 0.0 mg/L, respectively (Table 1 and Plate 1). Days required for callus initiation was also influenced by the supplementation of different concentration of 2, 4-D (Table l). Concentration of 2.5 mg/L required the maximum days (21.70) for internode while the same concentration required minimum days (18.10) for leaf explants for callus induction. These results on the effects of different concentrations are in conformity with

Plate 1. Different concentrations of 2, 4-D had shown significant variation for days required for shoot and root initiation

many other workers (Song *et al.*, 1987; Martel and Garcia, 1992; Omidi *et al.*, 1992) who also observed different days requirement of callus initiations (Table 1 and Plate 2). The combined effect of different concentrations of 2, 4-D and explant on the callus diameter was significant. The largest (7.80 mm) and lowest (3.10 mm) callus diameter were observed in leaf with the concentration of 2.50 mg/L and 0.0 mg/L, respectively (Table l). The effect of different concentrations of 2, 4-D on callus weight showed no significant differences. At 2.50 mg/L 2, 4-D had the highest weight of callus (0.309 g) in leaf explants. The lowest weight of callus (0.061 g) was found in internode with 0.0 mg/L 2, 4-D (Table 1).

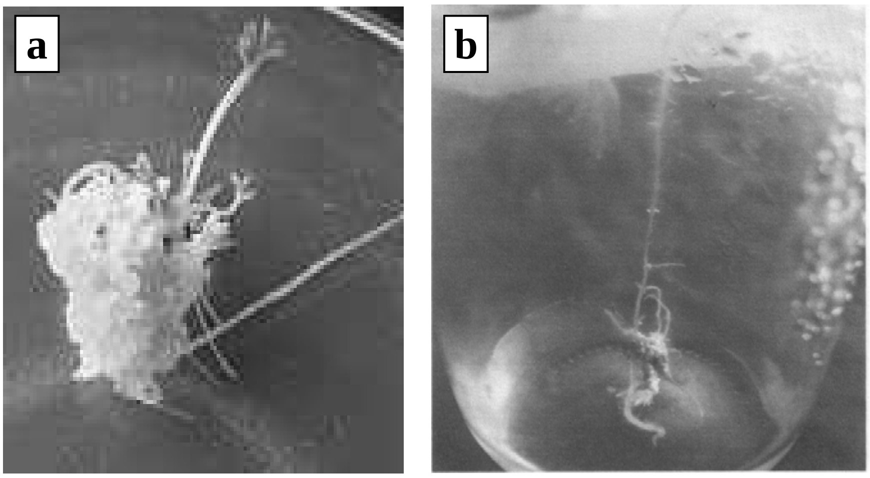

Plate 2. Shoot induction from leaf explant of potato at 1.5 mg /L NAA + 2.0 mg/L BAP at (a) 10 DAI and (b) 20 DAI, respectively

Table 1. Effect of 2, 4-D on the number of callus petridis^{-1}, days to callus initiation, callus diameter and callus weight (g) with different concentrations

Treatments Explants	Combinations 2, 4-D mg/L	Callus formation (%)	Days to callus initiation	Callus diameter (mm)	Callus weight (g)
Leaf	0	23.34c	21.583	3.127h	0.072d
	1.5	71.67ab	20.417	7.302c	0.286ab
	2.5	80.0 a	18.083	7.873a	0.309a
	3.5	71.67ab	21.417	7.052d	0.215c
Internode	0	25.0c	18.900	3.853g	0.061d
	1.5	70.2b	20.033	7.653b	0.278b
	2.5	72.34ab	21.700	6.521f	0.296ab
	3.5	72.34ab	21.533	6.77e	0.199c
	CV (%)	19.68	2.87	2.66	10.85
* Significant at 5% level		*	NS	*	*

NS = Not significant

In a column, means followed by common letter(s) do not differ significantly at 5% level by DMRT.

Effect of NAA on shoot regeneration

It was observed that different concentrations of NAA showed significant differences in number of shoots/explant. The maximum number of shoots (5.16), shoot length (4.02 cm) and the highest number of leaves (7.02) were produced from leaf explants with 1.5 mg/L NAA treatments; the minimum number of shoots (2.08), shoot length (1.30 cm) and the lowest number of leaves (1.66) were produced from leaf explants with 0.0 mg/L NAA. But Concentration 2.0 mg/L of NAA had taken maximum days (20.66) in internode (Table 2).

Table 2. Effect of NAA on *in vitro* shoot regeneration of potato

Treatments	Combinations	Shoots explant^{-1} (no.)	Days to shoot induction	Shoot length (cm)	Leaves plantlet^{-1} (no.)
Explants	NAA mg/L				
Leaf	0	2.167d	16.667	1.408d	1.75e
	1.0	5.00ab	20.000	3.80b	4.917b
	1.5	5.167a	19.833	4.025a	7.021a
	2.0	4.583bc	20.417	3.075c	4.572bc
Internode	0	2.083d	16.583	1.30d	1.667e
	1.0	5.00ab	20.000	3.733b	4.417cd
	1.5	4.50bc	20.500	3.858ab	6.750a
	2.0	4.333c	20.667	2.917c	4.250d
CV (%)		14.50	3.08	7.04	12.44
* Significant at 5% level		*	NS	*	*

NS = Not significant
In a column, means followed by common letter(s) do not differ significantly at 5% level by DMRT.

Effect of BAP on shoot regeneration

Different concentrations of BAP on the number of shoot/explant showed significant differences. The maximum number of shoots (5.26), shoot length (4.01cm) and the highest number of leaves (4.91) were produced in leaf explants with 2.0 mg/L BAP treatments; and the minimum number of shoots (2.50), shoot length (1.62) and the lowest number of leaves (3.45) with 0.0 mg/L BAP treatments. Concentration 1.0 mg/L BAP had taken maximum days (21.33) in internode (Table 3).

Table 3. Effect of BAP on *in vitro* shoot regeneration of potato

Treatments	Combinations	Shoots explant^{-1} (no.)	Days to shoot induction	Shoot length (cm)	Leaves plantlet^{-1} (no.)
Explants	BAP mg/L				
Leaf	0	2.833f	15.917	1.992g	3.917e
	1	4.333d	20.667	3.342d	4.583c
	2	5.267a	19.833	4.017a	4.917a
	3	4.483cd	20.417	2.958e	4.833ab
Internode	0	2.500g	16.250	1.617h	3.450f
	1	3.667e	21.333	3.492c	4.30d
	2	5.000ab	20.000	3.850b	4.667bc
	3	4.750bc	20.250	2.850f	4.667bc
	CV (%)	14.50	3.08	7.04	12.44
* Significant at 5% level		*	NS	*	*

NS = Not significant
In a column, means followed by common letter(s) do not differ significantly at 5% level by DMRT.

Interaction effect of NAA and BAP on shoot regeneration

The combined effects between different concentrations of NAA and BAP showed significant differences on the number of shoots/explants (Table 4). Maximum number of shoots (7.33), longest shoot (5.66 cm) and the highest number of leaves (7.66) were produced from leaf explant by the combination of 1.5 mg/L NAA + 2.0 mg/L BAP. Minimum number of days (17.66) was required for shoot initiation in 1.5 mg/L NAA + 2.0 mg/L BAP (Table 4). Minimum number of shoots (2.33), shortest shoots (1.53 cm), lowest number of leaves (1.00) and maximum number of days (17.66) were required for shoot initiation with 0.0 mg/L NAA + 1.0 mg/L BAP

Table 4. Combined effects of NAA and BAP on *in vitro* shoot regeneration of potato

Treatment	Combinations		Shoots explant^{-1} (no.)	Days to shoot induction	Shoot length (cm)	Leaves plantlet^{-1}
Explant	NAA (mg/L)	BAP (mg/L)				
Leaf	0	0	0.000j	0.000	0.000h	0.000l
		1	2.667hi	21.667	1.733efg	1.333k
		2	2.667hi	22.333	1.90efg	2.333j
		3	3.333ghi	21.333	2.00ef	3.333hi
	1.0	0	3.333ghi	21.667	2.667d	3.667gh
		1	5.00cde	20.000	3.500c	4.333fgh
		2	6.333a	19.667	5.567a	5.333def
		3	5.333bcd	19.667	3.467c	6.333a

Table 4 Contd.

Treatment Explant	Combinations NAA (mg/L)	BAP (mg/L)	Shoots explant^{-1} (no.)	Days to shoot induction	Shoot length (cm)	Leaves plantlet^{-1}
	1.5	0	3.333	21.667	1.70efg	6.667bc
		1	5.333bcd	19.667	4.40b	7.333ab
		2	7.333a	17.667	5.667a	7.667a
		3	4.667cdef	20.333	4.333b	6.333bcd
	2.0	0	4.667cdef	20.333	3.600c	5.333def
		1	4.667cdef	20.333	3.733c	5.333def
		2	4.333defg	20.667	2.933d	4.333fgh
		3	4.667cdef	20.333	2.033e	3.333hi
Internode	0	0	0.000j	0.000	0.000h	0.000l
		1	2.333c	22.667	1.533g	1.000k
		2	2.667hi	22.333	1.767efg	2.333j
		3	3.333ghi	21.667	1.90efg	3.333hi
	1.0	0	4.00efg	21.000	2.60d	3.667gh
		1	5.333bcd	19.667	3.467c	3.667gh
		2	5.333bcd	19.667	5.467a	4.667efg
		3	5.333bcd	19.667	3.40c	5.667cde
	1.5	0	2.667hi	22.333	1.60fg	6.667bc
		1	3.333ghi	21.667	4.20b	6.667bc
		2	6.333b	18.667	5.40a	7.333ab
		3	5.667bc	19.333	4.233b	6.333bcd
	2.0	0	3.333ghi	21.667	3.467c	4.667efg
		1	3.667fgh	21.333	3.567c	4.667efg
		2	5.667bc	19.333	2.767d	4.333fgh
		3	4.667cdef	20.333	1.867efg	3.333hi
CV (%)			14.50	3.08	7.04	12.44
* Significant at 5% level			*	NS	*	*

NS = Not significant
In a column, means followed by common letter(s) do not differ significantly at 5% level by DMRT.

Effect of IAA on root formation

In case of root formation, it was observed that different concentrations of IAA on the number of roots per shoot appeared significant differences (Table 5). The highest (9.58) and the lowest (3.83) number of roots were observed from leaf explants with 2.0 mg/L and 0.0 mg/L of IAA, respectively (Table 5). Different concentrations of IAA statistically affected the length of root after 28 days. From leaf explants, the highest root length (3.01 cm) was observed with 2.0 mg/L IAA and the lowest root length (0.65 cm) was with 0.0 mg/L of IAA. From internode, the highest (2.84 cm) and the lowest (0.54 cm) root lengths were observed with 2.0 mg/L and 0.0 of IAA, respectively (Table 5).

Table 5. Effect of IAA on *in vitro* root formation of potato

Treatments	Combinations	Roots shoot^{-1} (no.)	Root length (cm)
Explants	IAA (mg/L)		
Leaf	0	3.833c	0.650d
	1.0	7.500b	2.789b
	2.0	9.583a	3.014a
	3.0	7.250b	2.065c
Internode	0	4.250c	0.542d
	1.0	6.833b	2.723b
	2.0	9.167a	2.848ab
	3.0	7.000b	1.907c
CV (%)		11.32	10.32

In a column, means followed by common letter(s) do not differ significantly at 5% level by DMRT.

Effect of IBA on root formation

Different concentrations of IBA showed significant differences on the number of roots/shoot (Table 6). Maximum (7.5) and minimum (5.91) number of roots/shoot were appeared from leaf explants with 1.5 mg/L and 0.0 mg/L of IBA, respectively (Table 6). Different concentrations of IBA on root length after 28 days appeared significant differences. For leaf explant, maximum (3.003 cm) and minimum (1.23 cm) root lengths were with 1.0 mg/L and 0.0 mg/L of IBA, respectively. For internode, the highest (2.83 cm) and the lowest (1.15 cm) root lengths were observed with 1.0 mg/L and 0.0 mg/L of IBA, respectively (Table 6).

Table 6. Effect of IBA on *in vitro* root formation of potato

Treatments	Combinations	Roots shoot^{-1} (no.)	Root length (cm)
Explants	IBA mg/L		
Leaf	0	5.917f	1.233e
	0.5	7.333abc	2.330b
	1.0	7.417ab	3.003a
	1.5	7.50a	1.952cd
Internode	0	6.333e	1.158e
	0.5	6.667d	2.180bc
	1.0	7.167bc	2.837a
	1.5	7.083c	1.843d
CV (%)		11.32	10.32

In a column, means followed by common letter(s) do not differ significantly at 5% level by DMRT.

Interaction effect of IAA and IBA on root induction

Interaction effect of different concentrations of IAA and IBA on the number of roots showed significant differences (Table 7). The highest number of roots/shoot (10.33) was observed in leaf with 2.0 mg/L IAA + 1.0 mg/L IBA, while the lowest number of roots (3.00) was observed in internode with the combination of 0.0 mg/L

Table 7. Combined effect of IAA and IBA on *in vitro* root regeneration of potato

Treatments	Combinations		Roots shoot^{-1}	Root length
Explants	IAA (mg/L)	IBA (mg/L)	(no.)	(cm)
Leaf	0	0	0.000p	0.000h
		0.5	4.000no	0.727efg
		1.0	5.000m	0.880efg
		1.5	6.333ijklm	0.993ef
	1.0	0	6.333ijklm	1.657d
		0.5	7.00ghijk	2.487c
		1.0	7.333fghij	4.553a
		1.5	9.333abcd	2.460c
	2.0	0	9.333abcd	0.693efg
		0.5	10.000ab	3.383b
		1.0	10.333a	4.653a
		1.5	8.667bcdef	3.327b
	3.0	0	8.00defgh	2.583c
		0.5	8.333cdefg	2.723c
		1.0	7.00ghijk	1.927d
		1.5	5.667klm	1.027e
Internode	0	0	3.000 o	0.000h
		0.5	3.000 o	0.527g
		1.0	5.000m	0.747efg
		1.5	6.00jklm	0.893efg
	1.0	0	5.667klm	1.590d
		0.5	6.667hijkl	2.453c
		1.0	6.667hijkl	4.453a
		1.5	8.333cdefg	2.393c
	2.0	0	9.00abcde	0.593fg
		0.5	9.333abcd	3.183b
		1.0	9.667abc	4.387a
		1.5	8.667bcdef	3.227b
	3.0	0	7.667efghi	2.450c
		0.5	7.667efghi	2.557c
		1.0	7.333fghij	1.760d
		1.5	5.333lmn	0.860efg
CV (%)			11.32	10.32

In a column, means followed by common letter(s) do not differ significantly at 5% level by DMRT.

IAA + 0.0 mg/L IBA and 0.0 mg/L IAA + 0.5 mg/L IBA (Table 7). Interaction effect between the combination of IAA and IBA showed significant differences for root length after 28 days. The maximum root length (4.65 cm) was observed in leaf explant with 2.0 mg/L IAA + 1.0 mg/L IBA, while the lowest root length (0.53 cm) was observed in internode with 0.0 mg/L IAA+0.5 mg/L IBA (Table 7).

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EFFECT OF WEEDING AND UREA SUPER GRANULE APPLICATION ON THE GROWTH AND YIELD OF *BORO* RICE CV. BRRI dhan45

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Abstract

An experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from December 2008 to May 2009 with a view to find out the effect of weeding and Urea Super Granules (USG) fertilizer on the yield and yield characters of *Boro* rice BRRI dhan45. There were two sets of treatments; a) three weedings viz., no weeding, one weeding and two weeding and b) five levels of USG viz., control (no USG), one, two, three and four pellet (s) of USG per 4 hills, respectively. The experiment was laid out in a randomized complete block design with three replications. Grain and straw yields were the highest (4.00 and 5.78 t ha^{-1}, respectively) in two weedings. The lowest grain yield of 3.44 t ha^{-1} was obtained from no weeding. Level of USG significantly influenced all the plant characters, except; plant height, panicle length and weight of 1000-grain. Grain and straw yields were found the highest (4.44 and 5.89 t ha^{-1}, respectively) from the level of 4 pellets of USG per 4 hills. The interaction effect of weeding and level of USG had significant influence on all the crop characters under study, except plant height, panicle length and weight of 1000-grain. The finding of the study suggested that two weedings in combination with 4 pellets of USG per 4 hills gave the highest grain yield of 4.90 t ha^{-1} of the boro rice variety BRRI dhan45.

Key words: Boro rice (BRRI dhan45), Urea Super Granule (USG), Weeding.

Introduction

Rice (*Oryza sativa* L.) is the major food crop of Bangladesh. The area and production of rice in Bangladesh are about 10.37 million hectares and 25.16 million tons, respectively with an average yield of only 2.43 t ha^{-1}. Among the groups, transplanted Aman (T. *Aman*) rice covers about 50.92% of total rice area and contributes to 39.03% of total rice production in the country (Anonymous, 2009). The possibility of horizontal expansion of rice production area has come to a standstill (Hamid, 1991).

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Weeds compete with rice plants severely for space, nutrients, air, water and light; and adversely affect plant height, leaf architecture, tillering habit, shading ability, growth pattern and crop duration (Miah *et al*., 1990). The rice crops infested heavily with weeds can reduce the grain yields by 68-100% for direct seedbed *Aus* rice, 16-48% for *Aman* rice and 22% for modern *Boro* rice (Anonymous, 1998). According to Smith and Shaw (1999), weed depresses the normal yield of grains panicle^{-1} and grain weight. Yield loss depends upon some variables like magnitude of weed infestation, type of weed species and duration of weed associated with crop (Moody, 1998).

Nitrogen use efficiency for rice crop ranges between 25 and 35%, and seldom exceeds 50% (Singh and Yadav, 1985). The condition of wet land soil promotes N losses through ammonia volatilization, leaching and surface runoff when it is applied as prilled form in the soil surface. Urea super granules (USG) is a fertilizer that can be applied in the rice root zone at 8-10 cm depth of soil (reduced zone of rice soil) which can save 30% nitrogen compared to prilled urea (Savant *et al*., 1991). According to Crasswell and De Datta (1980), broadcast application of urea on the surface soil causes losses up to 50% but deep placement of USG in point may result in negligible loss. The savings of applied N reached 70 and 35 kg ha^{-1} when applied USG as N fertilizer during the *Boro* and *Aman* seasons, respectively (Bowen *et al*., 2005). Therefore, the aim of the study was to find suitable weed management practices and USG application on the growth and yield of boro rice.

Materials and Methods

The experiment was conducted at the Agronomy Field laboratory, Bangladesh Agricultural University, Mymensingh during the period from December 2008 to May 2009. The experimental area belongs to Sonatala soil series under Old Brahmaputra Flood plain (AEZ-9). The experimental field belongs to Non-calcareous Dark Grey Floodplain Soil. The field was a medium high land of silty loam soils having pH around 6.5. Two sets of treatments were imposed as; Factor A: weeding – 3: no weeding (W_0), one weeding (W_1) and two weedings (W_2) and Factor B: level of urea super granules (USG) – 5: control (No pellet of USG) ≈ 0 kg N ha^{-1} (N_0), one pellet of USG (1.8 g) per 4 hills ≈ 30 kg N ha^{-1} (N_1), two pellets of USG (3.6 g) per 4 hills ≈ 60 kg N ha^{-1} (N_2), three pellets of USG (5.4 g) per 4 hills ≈ 90 kg N ha^{-1} (N_3) and four pellets of USG (7.2g) per 4 hills ≈ 120 kg N ha^{-1} (N_4). The experiment was laid out in a randomized complete block design with three replications. Total number of unit plots were 45 (3 × 5 × 3). Spaces between blocks and unit plots were 1 m and 0.5 m, respectively. The size of unit plot was 10 m^2 (4.0 m × 2.5 m). The seeds started sprouting after 48 hours and became suitable for sowing in 72 hours. The nursery bed was made wet by application of water one day ahead of uprooting the seedlings. Thirty-one days old seedlings were uprooted carefully without causing any mechanical injury to the root. The seedlings were then transplanted on first January 2009 in the well puddled plots.

The plots were fertilized with 100, 75, 60 and 10 kg ha^{-1} of triple super phosphate, muriate of potash, gypsum and zinc sulphate, respectively at the time of final land preparation (Anonymous, 2004). As per experimental specification one, two, three or four pellet (s) of USG were placed manually at a depth of 6-8 cm at the centre of four hills of two adjacent rows at five days after transplanting.

Three seedlings were transplanted in each hill with a spacing of 25 cm × 15 cm. Seedlings in some hills died off and those were replaced by gap filling after one week of transplanting with seedlings from the same source. Weeding was done as per treatment. During weeding, different weed species grown in the experimental filed were identified. A constant level of standing water up to 5 cm was kept in early growth stage in the experimental field to enhance tillering and the water level was increased to some extent to discourage late tillering. The field was finally drained out before 15 days of harvest to enhance maturity. No remarkable infestation of insect or infection of disease was noticed in the field. Therefore, no plant protection measure was taken.

Five hills (excluding border hills) from each plot were randomly selected, uprooted and properly tagged before harvesting for recording of necessary data. The crop was harvested at full maturity when 90% of the grains turned golden yellow in colour. Grains were sun dried to a moisture content of about 14% and then weighed. Straw was also sun dried and weighed. Yields of both grain and straw were converted to t ha^{-1}. The following data were recorded: Plant height (cm), number of effective tillers hill^{-1}, panicle length (cm), number of grains panicle^{-1}, 1000-grain weight (g), grain yield (t ha^{-1}), straw yield (t ha^{-1}), biological yield (t ha^{-1}) and harvest index (%). Data on individual plant parameters were recorded from five randomly selected hills of each plot and those on grain yield, straw yield, biological yield and harvest index were recorded from the whole plot at harvest. The collected data were analyzed using the analysis of variance (ANOVA) technique and the significance of the mean differences were adjudged by Duncan's Multiple Range Test (Gomez and Gomez, 1984).

Results and Discussion

Effect of weeding

The effect of weeding on plant height (cm), panicle length (cm) and weight of 1000-grain did not show any significant difference (Table 1). On the other hand, number of effective tillers $hill^{-1}$, number of grains $panicle^{-1}$, grain yield (t ha^{-1}), straw yield (t ha^{-1}), biological yield (t ha^{-1}) and harvest index (%) showed significant difference (Table 1).

Pplant height (75.37 cm), number of effective tillers $hill^{-1}$ (18.05), panicle length (19.29 cm), number of grains $panicle^{-1}$ (62.7), weight of 1000-grain (27.72g), grain yield (4.00 t ha^{-1}), straw yield (5.78 t ha^{-1}), biological yield (9.77 t ha^{-1}) and harvest index (43.09%) obtained from two weedings showed insignificant difference (Table 1)

Effect of USG levels

The highest plant height (75.47cm) was obtained from application of 1 pellets of USG per 4 hills. Number of effective tillers $hill^{-1}$ (17.16), panicle length (19.63 cm), number of grains $panicle^{-1}$ (61.98), weight of 1000-grain (27.86 g), grain yield (4.44 t ha^{-1}), straw yield (5.89 t ha^{-1}) and biological yield (10.33 t ha^{-1}) was obtained from the application of 4 pellets of USG per 4 hills. In case of 4 pellets of USG per 4 hills, number of effective tillers $hill^{-1}$ was obtained 16.97 cm. Harvest index of 43.03%, 42.19% and 42.24% were recorded in 4, 3 and 2 pellets of USG per 4 hills, respectively.

Table 1. Effect of weeding on yield and plant characters of *Boro* rice cv. BRRI dhan45

Weeding	Plant height (cm)	Effective tillers $hill^{-1}$ (no.)	Panicle length (cm)	Grains $Panicle^{-1}$ (no.)	1000 grain wt. (g)	Grain yield (t ha^{-1})	Straw Yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
W_0	73.29	12.46c	19.29	46.42c	27.72	3.44b	4.74b	8.18b	41.81b
W_1	74.31	13.83b	19.25	53.91b	27.42	3.48b	4.60b	8.08b	43.09a
W_2	75.37	18.05a	19.39	62.74a	27.61	4.00a	5.78a	9.77a	40.79b
$S\bar{x}$	1.06	0.20	0.16	0.50	0.22	0.04	0.05	0.06	0.40
CV (%)	4.41	5.14	4.14	5.65	3.15	5.77	7.47	5.67	4.53

Weeding: W_0 = No weeding (Control), W_1 = One weeding, W_2 = Two weeding
In a column, means followed by common letter(s) do not differ significantly at 5% level by DMRT.

The lowest plant height (72.85cm) was obtained by the application of 3 pellets of USG per 4 hills. Number of effective tillers hill^{-1} (13.66cm), panicle length (19.03 cm) and number of grains panicle^{-1} (43.51) was obtained from the application of 1, 2 and no pellets of USG per 4 hills. In case of 2 pellets of USG per 4 hills, weight of 1000-grain (27.24g) was obtained. Grain yield (2.84 t ha^{-1}), straw yield (4.04 t ha^{-1}), biological yield (6.87 t ha^{-1}), harvest index (40.74%) was obtained from application of no pellets of USG per 4 hills (Table 2).

Table 2. Effect of USG levels on yield and plant characters of *Boro* rice cv. BRRI dhan45

USG Levels	Plant height (cm)	Effective tillers hill^{-1} (no.)	Panicle length (cm)	Grains panicle^{-1} (no.)	1000 grain wt. (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
N_0	74.85	11.46d	19.63	43.51d	27.86	2.84e	4.04d	6.87e	41.28b
N_1	75.47	13.66c	19.57	48.22c	27.67	3.31d	4.84c	8.15d	40.74b
N_2	73.96	14.66b	19.03	56.34b	27.24	3.64c	5.01c	8.66c	42.24ab
N_3	72.85	16.97a	19.10	61.76a	27.55	3.95b	5.43b	9.38b	42.19ab
N_4	74.48	17.16a	19.22	61.98a	27.60	4.44a	5.89a	10.33a	43.03a
$S_{\bar{X}}$	1.37	0.26	0.21	0.65	0.29	0.05	0.07	0.08	0.52
CV (%)	4.41	5.14	4.14	5.65	10.01	5.77	7.47	5.67	4.53

Levels of USG: N_0= No USG (Control), N_1= 1.8 g hill^{-1}, N_2=3.6 g hill^{-1}, N_3=5.4 g hill^{-1}, N_4=7.20 g hill^{-1}
In a column, means followed by common letter(s) do not differ significantly at 5% level by DMRT.

Interaction effect of USG and weeding

Plant height, panicle length, 1000-grain weight did not differ significantly due to the interaction between levels of USG and weeding but number of effective tillers hill^{-1}, number of grains panicle^{-1}, grain yield (t ha^{-1}), straw yield (t ha^{-1}), biological yield (t ha^{-1}) and harvest index (%) differed significantly (Table 3).

In case of plant height, the tallest plant (77.29 cm) was obtained in the interaction between two weedings and one pellet of USG per 4 hills and the lowest (69.86 cm) was obtained in the interaction between two weedings and three pellets of USG per 4 hills (Table 3). In case of effective tiller hill^{-1}, the highest number of effective tiller hill^{-1} (21.14) was obtained from the interaction between two weedings at 15 and 30 DAT and four pellets of USG per 4 hills, which was statistically identical with two weedings and three pellets of USG per 4 hills. The lowest number of effective tiller hill^{-1} (10. 47) was obtained from no weeding and no application of USG. The interaction did not show any significant effect on panicle length (Table 3).

Table 3. Interaction effect of weeding and level of USG on yield and plant characters of *Boro* rice cv. BRRI dhan45

Treatments	Plant height (cm)	Effective tillers hill^{-1} (no.)	Panicle length (cm)	Grains Panicle^{-1} (no.)	1000 grain wt. (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
W_0N_0	73.43	10.47e	19.24	37.35i	27.95	2.63h	4.09g	6.72h	39.11d
W_0N_1	74.89	12.96d	19.65	42.74h	27.34	3.13g	4.66f	7.79fg	40.22bcd
W_0N_2	73.37	11.33e	18.75	48.54g	27.07	3.41ef	4.63f	8.04f	42.42abc
W_0N_3	69.86	13.83d	19.10	53.70de	28.63	3.81cd	5.05e	8.86e	42.98ab
W_0N_4	74.89	13.72d	19.69	49.78fg	27.61	4.20b	5.28de	9.48cd	44.31a
W_1N_0	76.65	10.57e	19.76	41.14h	27.82	2.55h	3.38h	5.93i	42.94ab
W_1N_1	74.24	12.75d	19.11	48.03g	28.34	3.19fg	4.37fg	7.56g	42.29abc
W_1N_2	74.50	13.26d	18.85	56.35d	27.22	3.62de	4.55f	8.17f	44.31a
W_1N_3	72.93	16.13c	19.39	61.71c	26.55	3.85cd	5.11e	8.96e	42.93ab
W_1N_4	73.22	16.63c	19.13	62.33c	27.20	4.21b	5.58cd	9.79c	42.99ab
W_2N_0	74.45	13.53d	19.90	52.03ef	27.82	3.33fg	4.63f	7.96fg	41.81a-d
W_2N_1	77.29	15.27c	19.96	53.88de	27.32	3.62de	5.49d	9.11de	39.71cd
W_2N_2	74.00	19.37b	19.48	64.11c	27.43	3.90c	5.85bc	9.75c	39.99bcd
W_2N_3	75.75	20.93a	18.82	69.86b	27.47	4.20b	6.12b	10.32b	40.66bcd
W_2N_4	75.35	21.14a	18.82	73.83a	28.00	4.90a	6.83a	11.73a	41.80a-d
$S\bar{x}$	2.37	0.46	0.36	1.12	0.50	0.09	0.11	0.14	0.90
CV (%)	4.41	5.14	4.14	5.65	10.01	5.77	7.47	5.67	4.53

Weeding: W_0 = No weeding (Control), W_1 = One weeding, W_2 = Two weedings
Levels of USG: N_0 = No USG (Control), N_1 = 1.8 g hill^{-1}, N_2 = 3.6 g hill^{-1}, N_3 = 5.4 g hill^{-1}, N_4=7.20 g hill^{-1}
In a column, means followed by common letter(s) do not differ significantly at 5% level by DMRT.

The highest grains panicle^{-1} (73.83) was found in the interaction between two weedings and 4 pellets of USG per 4 hills. The lowest number of grains panicle^{-1} (37.35) was found in the interaction between no weeding and no USG application (Table 3). In case of straw yield, the highest straw yield (6.83 t ha^{-1}) was found in the interaction between two weedings and 4 pellets of USG per 4 hills. The lowest straw yield (4.09 t ha^{-1}) was obtained from the interaction between no weeding and no USG application (Table 3). In case of grain yield, it was observed that the highest grain yield (4.90 t ha^{-1}) was obtained from two weedings which was followed by the grain yield under the interaction of two weedings at 15 and 30 DAT and 4 pellets of USG per 4 hills. The lowest grain yield (2.55 t ha^{-1}) was obtained from the interaction between no weeding and no USG application (Table 3). In case of biological yield, it was observed that the highest biological yield (11.73 t ha^{-1}) was obtained from the interaction between two weedings and 4 pellets of USG per 4 hills. The lowest biological yield (6.72 t ha^{-1}) was obtained from the interaction between no weeding and no USG application (Table 3). In case of harvest index, it was observed that the highest harvest index (43.31%) was obtained from the interaction between no weeding and 4 pellets of USG per 4 hills which was statistically similar to the interaction between one weeding and 2 pellets of USG per 4 hills. The lowest harvest index (39.11%) was obtained from the interaction between no weeding and no USG application (Table 3).

Conclusion

From the experimental results, it elucidated that two weedings and application of four pellets of USG per 4 hills performed the best in respect of grain yield of the boro rice variety BRRI dhan45. Hence, two weedings and 4 pellets of USG weighting 7.2 g of each pellet by placing them in the center of four hills of two adjacent rows with the spacing of 25 cm × 15 cm could be suggested for higher yield of *Boro* rice variety BRRI dhan45.

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PERFORMANCE OF FINE RICE CV. KALIZIRA UNDER DIFFERENT DOSES OF FERTILIZER AND SPACING

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Abstract

An experiment was conducted at the Bangladesh Institute of Nuclear Agriculture (BINA) farm, Mymensingh, Bangladesh, during the period from July to December 2009 to determine the proper fertilizer dose and spacing for the best performance of a fine rice cv. Kalizira. The experiment consisted of three doses of fertilizer combinations, such as; (i) F_1= 75 kg N ha^{-1} + 60 kg P_2O_5 ha^{-1} + 45 kg K_2O ha^{-1} (ii) F_2= 50 kg N ha^{-1} + 40 kg P_2O_5 ha^{-1} + 30 kg K_2O ha^{-1} and (iii) F_3=25 kg N ha^{-1} + 20 kg P_2O_5 ha^{-1} + 15kg K_2O ha^{-1}; and three spacing, such as; (i) S_1= 20 cm × 20 cm (ii) S_2= 20 cm × 15 cm and (iii) S_3= 20 cm × 10 cm. The cultivar Kalizira showed the best performance at 50 kg N ha^{-1} + 40 kg P_2O_5 ha^{-1} + 30 kg K_2O ha^{-1} fertilizer dose and in 20 cm × 15 cm spacing. Yield increased from 2.89 t ha^{-1} (at fertilizer dose of 25 kg N ha^{-1} + 20 kg P_2O_5 ha^{-1} + 15kg K_2O ha^{-1}) to 3.33 t ha^{-1} (at the fertilizer dose of 50 kg N ha^{-1} + 40 kg P_2O_5 ha^{-1} + 30 kg K_2O ha^{-1}), but the yield decreased to 2.60 t ha^{-1} (at the fertilizer dose of 75 kg N ha^{-1} + 60 kg P_2O_5 ha^{-1} + 45 kg K_2O ha^{-1}). High dose of fertilizer produced the lowest yield because of lodging problem occurred at this dose. On the other hand, 20 cm × 15 cm spacing produced higher yield (3.15 t ha^{-1}) than 20 cm× 20 cm and 20 cm × 10 cm spacing which produced a yield of 2.75 t ha^{-1} and 2.92 t ha^{-1}, respectively. From the results, it might be concluded that fertilizer dose of 50 kg N ha^{-1}, 40 kg P_2O_5 ha^{-1} and 30 kg K_2O ha^{-1} with 20 cm × 15 cm spacing is the best combination for getting higher grain yield of Kalizira rice.

Key words: Fertilizer dose, Fine rice, Grain yield, Spacing

Introduction

Rice is one of the major cereal crops of the world. About 90% of the total rice grown in the world is produced by 200 million small farmers and rice is the major staple crop of nearly half of the world's population (Zeigler and Barclay, 2008; Khush, 2004). In Bangladesh, rice dominates over all other crops and covers 75% of the total cropped area (Rekabdar, 2004) of which around 27% is occupied by fine rice varieties (Anonymous, 2003). Rice is the source of 27% of dietary energy and 20% of dietary protein in the developing world (Redona, 2004). Kalizira is a local variety of fine rice,

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having special appeal for fragrance/aroma used for palatable dishes. Its market price is high, both in national and international market. So, its export can bring considerable amount of foreign exchange for the nation. But yields of the local aromatic rice varieties are low.

The reason for such low yield is mainly associated with cultivation technologies. Among the cultivation technologies, application of fertilizer and planting density are the important factors. Plant spacing plays a significant role on growth, development and yield of rice at its optimum level. Besides, it provides scope to the plants for efficient utilization of solar radiation and nutrients (Miah *et al*., 1990). Selection of appropriate fertilizer doses and plant spacing are most important issues for maximizing rice production. It is necessary to find out the optimum rate of N, P and K fertilizer for efficient utilization of those elements by rice plants for the best performance in yield. Therefore, the present study was conducted with the following objectives; i) to determine proper fertilizer doses ii) to find out the effect of plant spacing on the yield and yield components of the fine rice cv. Kalizira in aman season and iii) to find out the interaction between fertilizer doses and spacing on yield and yield components of the fine rice cv. Kalizira in aman season.

Materials and Methods

The experiment was conducted at the Bangladesh Institute of Nuclear Agriculture (BINA) farm, Mymensingh during the period from July to December 2009 in aman season to find out the optimum fertilizer dose and plant spacing for a fine rice vatiety cv. Kalizira. The experiment consisted of three fertilizer doses, such as; i) F_1 (75 kg N ha^{-1} + 60 kg P_2O_5 ha^{-1} + 45 kg K_2O ha^{-1}) ii) F_2 (50 kg N ha^{-1} + 40 kg P_2O_5 ha^{-1} + 30 kg K_2O ha^{-1}) and iii) F_3 (25 kg N ha^{-1} + 20 kg P_2O_5 ha^{-1} + 15 kg K_2O ha^{-1}); and three spacing, such as; i) S_1 (20 cm × 20 cm) ii) S_2 (20 cm × 15 cm) and iii) S_3 (20 cm × 10 cm). The experiment was carried out in a split plot design with four replications accommodating fertilizer doses in main plots and plant spacing in split plots. The unit plot size was 4.0 m × 3.0 m. Muriate of potash and triple superphosphate were applied during the final land preparation according to treatment specification. Nitrogen (N) was splited into thrice; one third of N as basal doses, one third of N at 30 days after transplanting and the rest of nitrogen was applied at panicle initiation stage (Anonymous, 2001). All the management practices were done in proper time starting from land preparation to crop harvest. The collected data were then statistically analyzed and mean differences were compared by Duncan’s Multiple Range Test (DMRT) (Steel and Torrie, 1980).

Results and Discussion

Yield and yield contributing characters were significantly influenced by fertilizer doses (Table 1). Among the treatments, the highest plant height (154.4 cm), number of total tiller hill^{-1} (10.25), number of effective tiller hill^{-1} (8.68) and the number of grains panicle^{-1} (122.34) were produced in F_2 (50 kg N ha^{-1} + 40 kg P_2O_5 ha^{-1} + 30 kg K_2O ha^{-1}). However, the highest grain yield (3.33 t ha^{-1}) was obtained in F_2 (50 kg N ha^{-1} + 40 kg P_2O_5 ha^{-1} + 30 kg K_2O ha^{-1}) while the lowest was recorded in F_3 (25 kg N ha^{-1} + 20 kg P_2O_5 ha^{-1} + 15 kg K_2O ha^{-1}) treatment. Straw yield (7.04 t ha^{-1}) and harvest index (32.09 %) were highest in F_2 (50 kg N ha^{-1} + 40 kg P_2O_5 ha^{-1} + 30 kg K_2O ha^{-1}) dose whereas the lowest were obtained in F_1 (75 kg N ha^{-1} + 60 kg ha^{-1} P_2O_5 + 45 kg K_2O ha^{-1}) dose followed by F_3 (25 kg N ha^{-1} + 20 kg P_2O_5 ha^{-1} + 15 kg K_2O ha^{-1}). In the treatment F_1 (75 kg N ha^{-1} + 60 kg P_2O_5 ha^{-1} + 45 kg K_2O ha^{-1}), excessive availability of nutrient especially N caused lodging and mutual shading. Almost every farmer has a tendency to apply more N fertilizer to get a desirable yield of rice (Saleque *et al*., 2004), but imbalance use of N fertilizer causes lodging of the crop and decreases grain yield.

Table 1. Effect of fertilizer on yield and yield contributing characters of fine rice cv. Kalizira

Fertilizer doses	Plant height (cm)	Tillers hill^{-1} (no.)	Effective tillers hill^{-1} (no.)	Panicle length (cm)	Grains panicle^{-1} (no.)	1000 grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
F_1	145.90b	9.53b	8.06b	19.63b	104.64c	11.45	2.60b	6.12b	29.14b
F_2	154.40a	10.25a	8.68a	21.96a	122.34a	11.50	3.330a	7.04a	32.09a
F_3	150.75a	9.73b	7.80b	19.78b	117.42b	11.09	2.89ab	6.28ab	32.06a
LSD value	4.22	0.28	0.28	1.617	3.24	-	0.47	0.79	2.51
CV (%)	2.04	2.26	2.34	5.44	3.70	5.62	9.55	4.72	7.11

F_1 (75 kg ha^{-1} N+ 60 kg ha^{-1} P_2O_5 + 45 kg ha^{-1} K_2O)
F_2 (50 kg ha^{-1} N+ 40 kg ha^{-1} P_2O_5 + 30 kg ha^{-1} K_2O)
F_3 (25 kg ha^{-1} N+ 20 kg ha^{-1} P_2O_5 + 15 kg ha^{-1} K_2O)
In a column, means followed by common letter(s) do not differ significantly at 5% level by DMRT.

Plant spacing exerted significant effect on yield and other yield contributing characters, except harvest index (Table 2). However, the highest plant height (156.28 cm) and harvest index (31.42 %) were obtained in the plant spacing S_3 (20 cm × 10 cm) and the lowest (143.87 cm) in spacing S_1 (20 cm × 20 cm). Though the maximum number of tillers hill^{-1} (11.41) and effective tillers hill^{-1} (10.15) were observed in spacing S_1 (20 cm × 20 cm), but the maximum number of grain panicle^{-1}, longest panicle length, grain yield and straw yield were recorded in spacing S_2 (20 cm × 15 cm).

The highest (3.15 t ha^{-1}) and the lowest (2.75 t ha^{-1}) grain yield were obtained in spacing S_2 (20 cm × 15 cm) and S_1 (20 cm × 20 cm), respectively. The highest straw yield (6.94 t ha^{-1}) was obtained in spacing S_2 (20 cm × 15 cm) and highest harvest index (31.42%) was obtained in spacing S_3 (20 cm× 10 cm). From the result, it could be realized that among these three spacing, spacing S_2 (20 cm × 15 cm) was the best for increasing the production of Kalizira rice.

The interaction effect of fertilizer and spacing on yield and yield contributing characters of the fine rice cv. Kalizira is shown in the Table 3. It was found that the interaction of fertilizer doses and plant spacing had significant influence on plant height, total tillers $hill^{-1}$ and effective tillers $hill^{-1}$. But the other crop characters were not significantly influenced by interaction. Interaction of F_2S_2 produced the highest grain yield (3.60 t ha^{-1}) and F_1S_1 produced the lowest grain yield (2.49 t ha^{-1}).

Table 2. Effect of plant spacing on yield and yield contributing characters of the fine rice cv. Kalizira

Plant spacing	Plant height (cm)	Tillers $hill^{-1}$ (no.)	Effective tillers $hill^{-1}$ (no.)	Panicle length (cm)	Grains $panicle^{-1}$ (no.)	1000 grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
S_1 (20cm × 20cm)	143.87c	11.41a	10.15a	20.24ab	114.28b	11.53	2.75b	6.17b	30.77
S_2 (20cm × 15cm)	150.30b	9.81b	8.14b	22.04a	125.09a	11.40	3.15a	6.94a	31.10
S_3 (20cm × 10cm)	156.88a	8.30c	6.26c	19.09b	105.03c	11.11	2.92ab	6.33b	31.42
LSD value	5.39	0.3924	0.3379	2.512	7.468	-	0.3239	0.5385	-
CV (%)	2.04	2.26	2.34	5.44	3.70	5.62	9.55	4.72	7.11

In a column, means followed by common letter(s) do not differ significantly at 5% level by DMRT.

Table 3. Interaction effect of fertilizer and spacing on yield and yield contributing characters of the fine rice cv. Kalizira

Interaction of fertilizer doses × spacings	Plant height (cm)	Tillers $hill^{-1}$ (no.)	Effective tillers $hill^{-1}$ (no.)	Panicle length (cm)	Grains $panicle^{-1}$ (no.)	1000 grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
F_1S_1	138.94e	11.57a	10.50a	19.7	101.03	11.73	2.49	5.98	29.42
F_1S_2	143.88d	98.02a	7.48e	20.74	116.48	11.62	2.71	6.74	28.66
F_1S_3	154.90abc	8.00g	6.21g	18.47	96.43	10.99	2.59	6.13	29.33
F_2S_1	150.58c	11.85a	10.65a	21.32	124.13	11.69	3.14	6.65	32.09
F_2S_2	154.38abc	10.41c	8.78c	24.49	129.68	11.62	3.60	7.45	32.60
F_2S_3	158.23a	8.50f	6.61f	20.06	113.80	11.19	3.25	7.04	31.59
F_3S_1	142.08de	10.80b	9.28b	19.710	117.68	11.17	2.62	5.89	30.80
F_3S_2	152.65bc	10.02d	8.13d	20.90	129.10	10.96	3.13	6.65	32.04
F_3S_3	157.52ab	8.38f	5.98g	18.71	104.88	11.16	2.91	5.82	33.34
LSD value	4.556	0.3322	0.2858	--	--	--	--	--	--
CV (%)	2.04	2.26	2.34	5.44	3.70	5.17	9.55	4.72	7.11

F_1 (75 kg ha^{-1} N+ 60 kg ha^{-1} P_2O_5 + 45 kg ha^{-1} K_2O), F_2 (50 kg ha^{-1} N+ 40 kg ha^{-1} P_2O_5 + 30 kg ha^{-1} K_2O)
F_3 (25 kg ha^{-1} N+20 kg ha^{-1} P_2O_5+15 kg ha^{-1} K_2O), S_1 (20 cm×20 cm), S_2 (20cm ×15cm) and S_3 (20cm ×10cm)
In a column, means followed by common letter(s) do not differ significantly at 5% level by DMRT.

Conclusion

From the study, it revealed that the fertilizer dose of 50 kg N ha^{-1}, 40 kg P_2O_5 ha^{-1} and 30 kg K_2O ha^{-1} with plant spacing of 20 cm × 15 cm performed the best to produce higher grain yield of the fine rice cv. Kalizira during the aman season.

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VARIATION IN MORPHOLOGICAL AND REPRODUCTIVE CHARACTERS AND THEIR RELATIONSHIP WITH SEED YIELD OF SOME ADVANCED LENTIL MUTANTS

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Abstract

A field experiment was conducted during November 2008 to March 2009 at the Bangladesh Institute of Nuclear Agriculture (BINA) farm, Mymensingh, Bangladesh with 10 promising lentil mutants along with mother variety BARI Masur-4 to evaluate some morpho-physiological features, reproductive characters and their impacts on seed yield. Results showed that high yielding mutants had the capacity to produce higher branches number, total dry mass production and leaf area, and better dry matter partitioning to economic yield and capacity to produce higher number of flowers than the low yielding ones. Among the 10 mutants, mutants LM-3-5 and LM-6-6 showed superiority in morpho-physiological characters which resulted to produce higher number of flowers and pods plant^{-1}, and thereby produced higher seed yield than the remaining mutants and the mother variety. Based on the superior morpho-physiological characters, yield attributes and seed yield, LM-3-5 and LM-6-6 might be selected for further trial at different agro-ecological zones of Bangladesh for confirmation of the results and registration as varieties.

Key words: Lentil, Morphological parameters, Mutants, Seed yield

Introduction

Lentil (*Lens culinaris* Medik), a pulse of global economic importance has been long domesticated. International endeavours to improve lentil have been promising in some cases (Erskine, 1998), but it is not the case everywhere. In South Asia, the yield of lentil remains low and average seed yield is below 1.0 t ha^{-1} (Anonymous, 2009). Lentil has been identified as a narrow adapted crop and the principal constraint of lentil production is its low yield potential because of undesirable plant type and high rate of flowers abscission (Samad *et al*., 2010). Important morpho-physiological attributes and photo-assimilate production capacity and its efficient partitioning to economic yield, etc. can address various constraints of a variety for increasing its

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productivity. Further, leaf area index (LAI) is a key physiological parameter to determine yield. A plant with optimum LAI may produce higher biological yield, thereby economic yield (Mondal *et al.*, 2013). The dry matter accumulation may be the highest if the LAI attains its maximum value within the shortest possible time (Mondal *et al.,* 2011). Samad *et al*. (2007) also suggested that the relationship between flower production and pod set in lentil is related to source leaf area (LA) and the increased seed yield could be achieved by increasing the source capacity. On the other hand, component characters for yield of lentil are interdependent on each other, while one character may express at the expense of other (Yadav *et al*., 2003). The importance of correlation study both at genotypic and phenotypic levels in any breeding programme is well documented for various crop species, as it provides a basis for effective selection of characters contributing to yield (Singh *et al.*, 2008).

Induced mutation breeding techniques have been utilizing in producing new varieties in lentil (Samad *et al*., 2006; Samad and Roy, 2008). The mutant varieties have been found to have high yield, dwarfness, early maturity, synchrony in pod maturity, disease resistance, stress tolerance, bolder seed size, improved quality and adaptability.

Recently BINA has developed 10 promising lentil mutants with early maturity, synchrony in pod maturity and resistance to diseases. These mutants need to be evaluated for their morpho-physiological characters, yield attributes and seed yield and reproductive efficiency. Therefore, the present investigation was undertaken to assess the variability in these mutants and evaluate their morpho-physiological characters, yield attributes, seed yield and reproductive efficiency.

Materials and Methods

Ten mutants were selected in M_6 generation derived from BARI Masur-4 through induced gamma mutagenesis. Performance of ten promising mutants viz., LM-6-1, LM-1-2, LM-9-3, LM-7-4, LM-3-5, LM-6-6, LM-5-7, LM-2-8, LM-9-9, LM-1-10 and a check variety of BARI Masur-4 were evaluated at BINA farm during the rabi season of 2008-2009. The experiment was laid out in a randomized complete block design with three replications. Unit plot size was 4 m × 3 m. Seeds were sown in line of 30 cm apart and two weeks after germination, the plants were thinned to 6-8 cm distance between the plants. Recommended intercultural practices, such as; weeding, thinning and application of pesticides were followed as and when necessitated for proper growth and development of the plants in each plot. Phosphorus and potash were provided during the final land preparation at the rates of 60 and 80 kg ha^{-1} in the form of triple super phosphate (TSP) and muriate of potash (MP), respectively. The experiment was set on 7 November 2008 and harvested on 25 February to 7 March 2009 depending on mutants. The number of opened flowers plant^{-1} was recorded from 15 randomly selected pants, 5 from each plot. The opened flowers were counted daily. Reproductive efficiency (Percent podset to opened flowers) was calculated as follows; % pod set = (Number of pods plant^{-1} ÷ Number of opened flowers plant^{-1}) × 100. Leaf area (LA) was measured by Automatic Leaf Area Meter (Model: LAI 3000, USA). Data on plant height, number of branches, total dry matter, yield and yield attributes were recorded at maturity from 10 randomly selected plants from each plot. The yield contributing characters were recorded at harvest from ten competitive plants of each plot. For total dry mass, five plants from each plot were separated into roots, stems, leaves and pods, and the corresponding dry weights were recorded after oven drying at 80 ± 2 ^{0}C for 72 hours. Harvest index was calculated using the formula as;

Harvest index = Economic yield/plot ÷ biological yield/plot) × 100.

The collected data were then analyzed statistically following the computer package programme, MSTAT-C.

Results and Discussion

Morphological characters

Genetic variations in morpho-physiological characters, such as; plant height, number of branches plant^{-1}, leaf area plant^{-1} and total dry matter (TDM) plant^{-1} were significant (Table 1). The tallest plant was recorded in LM-3-5 (39.3 cm) and this mutant also showed the highest number of branches plant^{-1} (22.0), leaf area (LA) plant^{-1} (466 cm^2) and TDM plant^{-1} (9.9 g) followed by LM-9-9. Similarly, taller genotypes also showed higher number of branches plant^{-1}, LA plant^{-1} and TDM plant^{-1}. These results indicated that production of branch number, LA and TDM had correlation with plant height. On the other hand, shorter genotypes had fewer number of branches plant^{-1} and LA plant^{-1}. The shortest plant (19.6 cm), lower number of branches plant^{-1} (13.2) and lowest leaf area plant^{-1} (344 cm^2) were observed in LM-5-7 followed by LM-6-1. Other mutants/variety were in intermediate group in plant height, branch number and LA plant^{-1}. Genotypic variation in morphological characters was also observed by Mondal *et al.* (2013) in lentil that supported the present experimental results. It was evident that some mutants were taller having higher number of branches plant^{-1}, LA plant^{-1} and TDM plant^{-1} while others were shorter having less number of branches plant^{-1}, lower LA and TDM plant^{-1} than check variety, which created variability in respect of morpho-physiological characters, possibly due to gamma radiation. These results were in agreement with the result of Samad *et al.* (2007) who reported that variation in plant height, production of branches, LA and TDM was created through induced gamma ray irradiation.

Phenological and reproductive characters

Variation in days to first flowering, days to maturity, flowering duration and reproductive efficiency (RE) due to genotypes was significant (Table 1). Results indicated that most of the mutants were early flowering and maturity capacity than the check cultivar BARI Masur-4, except LM-2-8. The mutant LM-2-8 showed delay flowering and maturity than the mother variety BARI Masur-4. These results indicated that the possibility of early maturity by mutation breeding could be achieved. The short duration was recorded in LM-7-4 whereas long duration plant was observed in LM-2-8. Results indicated that in general, long duration flowering genotypes produced higher number of flowers plant^{-1} with lower reproductive efficiency (RE). The highest flowering duration was recorded in LM-6-6 (38.2 days) and this mutant also produced the highest number of flowers plant^{-1} (297). In contrast, the shortest flowering duration (22.2 days) was observed in LM-6-1 and this mutant also produced the lowest number of flowers plant^{-1} (92). This result indicated that flower production positively depended on flowering duration. Samad *et al*. (2010) reported that higher flower producing genotypes had longer flowering duration. RE did not show any relation with flower production and flowering duration.

Table 1. Some morphological, reproductive and phenological characters of lentil mutants/ cultivar

Genotypes	Plant height (cm)	Branches plant^{-1} (no.)	Leaf area plant^{-1} (cm^2)	TDM plant^{-1} (g)	Days to first flowering	Days to maturity	Flowering duration	Flowers plant^{-1} (no.)	Pod set to opened flowers (%)
LM-6-1	24.9 d	12.5 f	370 c	6.32 g	65 ab	100 cd	22.2 h	92 e	58.5 a
LM-1-2	33.6 b	19.8 bc	424 b	7.00 f	60 d	99 cd	25.0 g	211 c	48.9 cd
LM-9-3	30.6 bc	21.0 ab	406 bc	7.60 de	62 cd	100 cd	27.5 f	202 c	49.9 c
LM-7-4	33.1 b	16.8 e	390 c	9.20 b	51 e	95 e	30.8 cde	217 c	43.9 ef
LM-3-5	39.3 a	22.0 a	466 a	9.90 a	61 cd	97 de	29.5 ef	263 b	52.5 bc
LM-6-6	29.7 bc	20.0 bc	436 ab	8.02 c	61 cd	98 de	38.2 a	297 a	45.0 de
LM-5-7	19.6 e	13.2 f	344 e	5.02 h	63 bc	102 bc	32.0 ed	177 d	33.0 g
LM-2-8	26.8 c	17.0 de	400 b	7.57 de	66 a	108 a	36.0 b	263 b	34.3 g
LM-9-9	37.5 a	16.8 e	361 d	6.07 g	63 bc	98 de	35.5 b	251 b	39.6 f
LM-1-10	29.5 c	18.5 cd	411 b	7.20 ef	62 cd	97 de	29.8 def	200 e	56.1ab
BARImasur-4	31.4 bc	13.5 f	389 cd	7.62 d	65 ab	104 b	32.8 e	210 c	48.4 cde

In a column, means followed by common letter(s) do not differ significantly at 5% level by DMRT.

The highest RE was recorded in LM-6-1 (58.5%), the low flower producing mutant while the second highest RE was observed in LM-1-10 (48.4%). The lower RE was observed in two mutants of LM-5-7 and LM-2-8. Genotypic variation in RE was also observed by Samad *et al.* (2010) in lentil and the authors reported that flower production and RE had reverse trend. In the present experiment, low flower producing mutants showed high RE in lentil that supported the earlier statement.

Yield attributes and seed yield

Results revealed that LM-3-5 produced the highest seed yield both in per plant (4.25 g) and per hectare (1534 kg) followed by LM-6-6 (4.07 g plant^{-1} and 1498 kg ha^{-1}) with same statistical rank (Table 2). The yield was higher in these two mutants due to production of higher number of pods plant^{-1} and bolder seeds. The harvest index was also superior in these two mutants. In contrast, the lower seed yield was recorded in LM-5-7 (767 kg ha^{-1}), LM-9-3 (853 kg ha^{-1}) and LM-6-1 (962 kg ha^{-1}) due to inferiority in yield attributes and also poor dry matter partitioning to economic yield. Mondal *et. al.* (2013) reported that genotypes having better dry matter partitioning to economic yield also performed better to produce higher seed yield in lentil.

Table 2. Variations in yield attributing characters of lentil mutants/variety

Genotypes	Pods plant^{-1} (no.)	seeds pod^{-1} (no.)	Seeds plant^{-1} (no.)	1000-seed weight (g)	Seed yield plant^{-1} (g)	Seed yield (kg ha^{-1})	Harvest index (%)
LM-6-1	54.0 d	1.42 abc	77.0 f	23.83 b	2.58 g	862 e	27.87 b
LM-1-2	103.0 c	1.14 e	118.0 e	23.56 bc	3.18 c	1172 c	30.64 a
LM-9-3	101.0 c	1.37 c	137.0 cd	23.53 bc	2.58 g	853 f	20.18 c
LM-7-4	95.5 c	1.35 c	128.0 de	20.54 d	3.60 c	1100 cd	21.91 c
LM-3-5	138.5 a	1.35 c	196.0 a	24.03 b	4.25 a	1534 a	28.22 b
LM-6-6	130.0 a	1.51 a	201.0 a	26.14 a	4.07 a	1498 a	32.19 a
LM-5-7	58.5 d	1.20 de	71.0 f	22.74 bc	2.70 fg	767 g	21.75 c
LM-2-8	120.0 b	1.35 c	173.0 b	22.19 c	3.45 cd	1293 b	31.33 a
LM-9-9	100.0 c	1.41 bc	142.0 c	22.71 bc	2.88 f	1051 de	30.97 a
LM-1-10	112.5 b	1.49 ab	146.0 c	22.77bc	3.22 de	1188 c	27.98 b
BARImasur-4	112.0 b	1.34 d	150.0 c	22.79 d	3.95 b	1287 b	30.77 a

In a column, means followed by common letter(s) do not differ significantly at 5% level by DMRT.

Correlation study

Pod number is the prime yield attributes in lentil. Pod number showed significant and positive correlations with branch number (r = 0.73**), LA (r = 0.61**), flower number (r = 0.86**) and TDM (r = 0.69**) thereby these parameters showed highly significant positive correlation with seed yield (Table 3). In contrast, pod number had negative association with reproductive efficiency (RE), days to first flowering and days to maturity. This suggested that increasing sink (pod number) production would increase seed yield, and pod production depends on morpho-physiological characters, not on reproductive efficiency and early flowering. These results are in agreement with the results of many researchers who also observed that seed yield increased with the increased number of pods plant^{-1} in lentil (Yadav *et al*., 2003; Anzam *et al*., 2005; Tabu and Sakar, 2008; Younis *et al*., 2008; Karadavut, 2009).

Table 3. Simple correlation coefficient among different quantitative characters in 11 lentil mutants/variety

Dependent variables	Independent variables										
	Pod plant^{-1} (no.)	Flowers plant^{-1} (no.)	Branches plant^{-1} (no.)	% Pod set	TDM plant^{-1}	Seed pod^{-1} (no.)	1000 seed weight	Days to first flowering	Flowering duration	Days to maturity	Leaf area plant^{-1} (cm^2)
Seed yield plant^{-1}	0.82**	0.59**	0.52**	0.28*	0.73**	0.25 NS	0.44	0.03NS	0.25NS	-0.07NS	0.58**
Pods plant^{-1} (no.)	---	0.86**	0.73**	0.05NS	0.69**	0.28 NS	0.23 NS	-0.05NS	0.48**	-0.07NS	0.61**
Flowers plant^{-1} (no.)		---	0.55**	-0.38*	0.47**	0.21NS	0.16 NS	-0.10NS	0.73**	-0.03NS	0.48**
Branches plant^{-1} (no.)			---	0.17NS	0.56**	0.17 NS	0.38*	-0.24NS	0.08NS	-0.32*	0.46**
% Pod set				---	0.27NS	0.23NS	0.22NS	-0.01NS	-0.62**	-0.41**	-0.33*
TDM plant^{-1}					---	0.17 NS	-0.03NS	-0.45**	0.06NS	-0.30*	0.69**

n = 33; * and ** indicate significant at 5% and 1% level of significance, respectively.
NS = Not significant

Conclusion

From the results, it could be concluded that in addition to superior yield contributing attributes, a high yielding lentil genotype should posses a relatively higher number of flowers with superior morpho-physiological parameters and capacity to better dry matter partitioning to economic yield. Among the tested mutants, due to having superior morpho-physiological characters and yield, LM-3-5 and LM-6-6 might be selected for further field trial at different agro-ecological zones of Bangladesh for confirmation of the results and registration as varieties. Moreover, generation of mutants having improved yield attributes over mother variety also suggested that gamma ray irradiation could be fruitfully applied to develop mutants with higher seed yield and other improved agronomic traits in lentil.

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PERFORMANCE OF LEAF BIOMASS AGAINST SHEATH BLIGHT AND BACTERIAL LEAF BLIGHT OF RICE

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Abstract

Well decomposed leaf biomass of Mehogoni, Neem, Arjun, Jam and Pitraj were incorporated into the experimental units during the Aman season of 2009 to control sheath blight and bacterial leaf blight of rice. The experiment was laid out following RCBD with 3 replications. Leaf biomass of five plant species were used as treatments. Disease index and severity were low in all the treatments, except Pitraj. Leaf biomass of Neem and Mehogoni were more effective in controlling sheath blight and bacterial leaf blight of rice. Consequently effective tillers and grain yield were higher where the leaf biomass was applied in comparison of the control plots.

Key words: Bacterial leaf blight, Leaf biomass, Rice, Sheath blight, Yield

Introduction

Sheath blight caused by *Rhizoctonia solani* is a major disease of rice in Bangladesh. World wide it is one of the most widespread and harmful fungal disease of rice (*Oryza sativa L.*) (Savary *et al.*, 2006). Sheath blight can cause up to 40% yield loss under optimum condition of disease development (Zhong *et al.,* 2007). Bhuvaneswari and Raju, (2013), reported that *R. solani* had a very wide host range and there is no resistant variety of rice. The soil borne nature of the pathogen and prolonged survival by its *sclerotia* makes difficult to control of this disease (Bhuvaneswari and Raju, 2013).

Bacterial leaf blight (BLB) of rice caused by *Xanthomonas oryzae* pv. *oryzae*, is an another major disease of rice in Bangladesh (Jalaluddin *et al.,* 2000). The disease decreases rice yield in all of Boro, Aus and Amon seasons.

The management strategies recommended are fungicide application and balanced plant nutrition (Rezende *et al.*, 2009). Chemical control is hazardous as it destroys ecological balance and causes resurgence of the pests. It is possible to control

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those diseases through different tree leaf biomass which has no adverse effect on the environment. On the other hand, crop cultivation reduces soil organic matter and adversely affect on soil quality (Begum, 2008). Soil compaction is the main reason for low soil organic matter, which restricts plant root development and limits plant growth (Unger and Kasper, 2004).

Leaf biomass are the good source of input of nutrients which are essential for plant growth and development. A large number of plants have been reported to produce antifungal and antibacterial substances (Begum, 2008). *Azadirachta indica* was highly toxic to *Fusarium oxysporum* showing complete inhibition of mycelial growth and spore germination at 100% concentration (Bansal and Gupta, 2000). Leaf biomass is a very effective method which reduces the chemicals and considered as one of the best strategy for preserving the nature without disturbing its components (Alam, 2010). Under this situation, the present study was under taken to assess the efficacy of leaf biomass of five plant species against *R. solani* and *X. oryzae* pv. *oryzae* of rice.

Materials and Methods

The experiment was conducted in the field laboratory, Department of Agroforestry, Bangladesh Agricultural University, Mymensingh during July to December, 2009. Rice variety BR 11 (Mukta) was used as the test crop. The experiment was laid out in a randomized complete block design with 3 replications. The unit plot size was 1 m × 1 m. The distance between two blocks was 100 cm and the plots were separated from each other by 40 cm space. The treatments were; T_1 = Mehogoni 100 g, T_2 = Mehogoni 150 g, T_3 = Mehogoni 300 g, T_4 = Neem 100 g, T_5 = Neem 150 g, T_6 = Neem 300 g, T_7= Arjun 100 g, T_8 = Arjun 150 g, T_9 = Arjun 300 g, T_{10} = Jam 100 g, T_{11} = Jam 150 g, T_{12} = Jam 300 g, T_{13} = Pitraj 100 g, T_{14} = Pitraj 150 g, T_{15} = Pitraj 300 g leaf biomass and T_{16} = Control (without leaf biomass) + Recommended dose of NPK Fertilizers (Anonymous, 2012). Well decomposed leaf biomasses were incorporated in the experimental plots before ten days of final land preparation. Recommended dose of all fertilizers, except nitrogen were applied in control plots during final land preparation. Nitrogen was splited thrice and 1/3 of N was applied as basel dose, 1/3 N at 30 days after transplanting and the rest of nitrogen was applied at panicle initiation stage. Forty days old seedlings were transplanted in the field. Under natural field condition, the occurrence of sheath blight and bacterial leaf blight were recorded from randomly selected 5 hills of each plot. The plants were graded using the following scoring scale (0 to 9) of Standard Evaluation System for Rice (Anonymous, 1999). The plants showing a mean disease score 0 were highly resistant, 1 resistant, 2 to 3 were moderately resistant, 4 to 5 tolerant, 6 to 7 moderately susceptible and 8 to 9 susceptible. Yield and yield contributing characters were recorded at harvesting stage of plants. The disease index and severity were estimated at dough stage using the following formulae:

$$\text{Percent disease index (PDI)} = \frac{\text{Sum of total scores}}{\text{Maximum scale} \times \text{Total number of plants assessed}} \times 100$$

Results and Discussion

There was significant difference among the treatments in percent disease index (PDI) of sheath blight and bacterial leaf blight of rice (Table 1). Percent disease index was the highest in T_{13}. It was 61.22% for sheath blight and 89.22% for leaf blight in T_{16}. In case of sheath blight, Neem at 150 g and 300 g were superior to the other

Table 1. Effect of leaf biomass on disease index and severity of sheath and bacterial leaf blight of rice

Treatments	Sheath blight		Bacterial leaf blight	
	Disease index (%)	Disease severity (0-9)	Disease index (%)	Disease severity (0-9)
T_1 Mehogoni (100 g m^{-2})	55.08d	5.0	60.64cdef	5.4
T_2 Mehogoni (150 g m^{-2})	51.00ef	4.6	59.13defg	5.3
T_3 Mehogoni (300 g m^{-2})	44.03gh	3.9	55.0fg	5.0
T_4 Neem (100 g m^{-2})	52.51de	4.7	56.46efg	5.0
T_5 Neem (150 g m^{-2})	43.64h	3.4	54.93fg	4.9
T_6 Neem (300 g m^{-2})	43.13h	3.4	53.82g	4.8
T_7 Arjun (100 g m^{-2})	51.02ef	4.5	66.86bc	6.0
T_8 Arjun (150 g m^{-2})	51.35def	4.6	64.91bcd	5.8
T_9 Arjun (300 g m^{-2})	46.11gh	4.1	63.82bcd	5.7
T_{10} Jaam (100 g m^{-2})	52.02de	4.6	63.82bcd	5.7
T_{11} Jaam (150 g m^{-2})	47.62fg	4.2	62.57bcde	5.6
T_{12} Jaam (300 g m^{-2})	44.95gh	4.0	60.97cdef	5.4
T_{13} Pitraj (100 g m^{-2})	66.33a	5.9	93.13a	8.3
T_{14} Pitraj (150 g m^{-2})	57.17c	5.1	87.57a	7.8
T_{15} Pitraj (300 g m^{-2})	53.91de	4.8	67.66b	6.0
T_{16} Control (Only RDF)	61.22b	5.5	89.22a	8.0
Level of significance	0.01	0.01	0.01	0.01

RDF = Recommended doses of fertilizers
In a column, means followed by common letter(s) do not differ significantly at 5% level by DMRT.

treatments. There was difference between T_1, T_2 and T_3 but no difference between T_5 and T_6. Similarly, T_4 did not differ from T_{12}. The difference between T_{10} and T_{11} was significant. Disease index of leaf blight was similar in T_1, T_2 and T_3. It was also similar in T_4, T_5 and T_6 but dissimilar between T_{14} and T_{15}. Disease index of sheath blight was similar in T_1 and T_4. It was also same for leaf blight. There was no difference between T_4 and T_{10}. The results revealed that effects of different treatments of leaf biomass were not consistent. In case of Mehogoni 100 g, 150 g and 300 g had significant difference but in case of Pitraj it was not different

Similar experiments were conducted by other workers (Begum, 2008; Alam, 2010) who reported that leaf biomass of Neem and Mehogoni were effective against fungi and bacteria. Leaf biomass of Mehogoni and Arjun were also effective against *R. solani* and *X. oryzae* pv. *oryzae*. In addition, (Alam, 2010) reported that leaf biomass of Pitraj was reported toxic to the pathogen of brown leaf spot of rice. Fungi toxicity of leaf biomass might be responsible for the presence of antifungal substances. Isolates of such substances from higher plants have been demonstrated to possess systemic activity and was less phytotoxic as compared with synthetic fungicides (Fawcett and Spencer, 1990).

The number of effective tillers, grains panicle^{-1} and grain yield (t ha^{-1}) were influenced by incorporation of leaf biomass (Table 2). The number of effective tillers, grains panicle^{-1} and yield were significantly higher in leaf biomass of Mehogoni at 300 g than that of any other treatments.

Number of effective tillers and grains panicle^{-1} increased by 29.98% and 17.32% in Mehogoni at 300 g over control. The number of effective tillers and grains panicle^{-1} ranged from 9.24 to 12.01 and 93.20 to 115.35, respectively. The treatment T_3 (Mehogoni at 300 g m^{-2}) was superior in producing higher number of effective tillers and number of grains panicle^{-1}. No significant difference was detected between T_3 and T_6.

The maximum grain yield (5.61 t ha^{-1}) was obtained from T_3. Yield of rice increased in T_2 and T_5 against the diseases. The minimum grain yield was recorded in T_{16} (control).

Table 2. Effect of leaf biomass on yield and yield contributing components of Aman rice

Treatments	Effective tillers hill^{-1} (no.)	Grains panicle^{-1} (no.)	Yield (t ha^{-1})	Yield increased over control (%)
T_1 Mehogoni (100 g m^{-2})	10.11 c	110.89 b	4.56 d	33.38
T_2 Mehogoni (150 g m^{-2})	9.61 de	105.97 c	4.98 b	45.61
T_3 Mehogoni (300 g m^{-2})	12.01 a	115.35 a	5.61 a	64.03
T_4 Neem (100 g m^{-2})	9.81 cd	99.74 de	4.11 e	20.17
T_5 Neem (150 g m^{-2})	11.45 b	109.72 b	4.94 bc	44.44
T_6 Neem (300 g m^{-2})	12.00 a	115.29 a	5.50 a	60.81
T_7 Arjun (100 g m^{-2})	9.25 efgh	96.70 defg	3.45 h	00.87
T_8 Arjun (150 g m^{-2})	8.61 ghi	96.28 efg	3.61 gh	05.55
T_9 Arjun (300 g m^{-2})	8.17 j	100.10 d	3.89 fg	13.74
T_{10} Jaam (100 g m^{-2})	8.61 hi	96.85 defg	4.14 ef	21.05
T_{11} Jaam (150 g m^{-2})	10.02 c	108.44 bc	4.66 cd	36.25
T_{12} Jaam (300 g m^{-2})	9.85 ef	105.30 c	4.65 cd	35.96
T_{13} Pitraj (100 g m^{-2})	8.25 j	93.89 fg	3.44 h	00.58
T_{14} Pitraj (150 g m^{-2})	8.26 ij	93.22 g	3.46 h	01.16
T_{15} Pitraj (300 g m^{-2})	7.86 j	93.20 g	3.55 h	03.80
T_{16} Control (Only RDF)	9.24 efg	98.32 de	3.42 h	-
Level of significance	0.05	0.05	0.05	-

RDF = Recommended dose of fertilizers

In a column, means followed by common letter(s) do not differ significantly at 5% level by DMRT.

Soil amended with leaf biomass of Mehogoni and Neem @ 300 g were effective in reducing disease index and increased the yield 64.0% and 60.8%, respectively of rice over control. Several workers had reported the effectiveness of leaf biomass and green manure in controlling the disease of different diseases and increasing yield of rice (Uddin, 2004; Alam, 2010).

Conclusion

It could be concluded that Neem and Mehogoni at 300 g m^{-2} were effective in reducing index and severity of sheath blight and bacterial leaf blight and increased the yield of rice.

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AVAILABILITY OF AGRICULTURAL INPUTS FOR CROP PRODUCTION: A CASE STUDY OF DHIGALGAON VILLAGE UNDER COMILLA SADAR UPAZILA

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Abstract

The study was conducted to find out the availability of agricultural inputs to the farmers on timely basis for crop production, such as; seeds, fertilizers, credit, irrigation materials, pesticides, etc. The study was based on the data collected from the farmers of the village Dhigalgaon under Comilla district. The areas covered under the study were; the farmers' socio-economic and demographic information, and sources and timely availability of the above agricultural inputs. The farmers socio-economic and demographic information included; age of the respondents, level of education, occupation of the respondents, income distribution, involvement of farmers in NGO, and cooperative society, credit received, pattern of land ownership, etc. The sources and timely availability of the agricultural inputs included; seeds, fertilizers, irrigation water, labor, pesticides, etc. The study revealed that all the required agricultural inputs were not timely available to the farmers in different reasons. So, the findings of the study suggested that GOs, NGOs and agricultural research institutes should take necessary steps for timely availability and supply of agricultural inputs to the farmers.

Key words: Agricultural inputs, Availability, Crop production

Introduction

Bangladesh is predominantly an agrarian and densely populated country in the world. The country has a total estimated population of 148.5 million and is projected to be 159.7 million by the year 2015 (Anonymous, 2011). Agriculture is regarded as the life line of Bangladesh economy. As a largest private enterprise in Bangladesh, agriculture (crops, livestock, fisheries and forestry) contributes about 23.50% of the GDP and seems to have managed to feed 150 million people of the country. The sector sustains the livelihood of about 52% of the labor force and remains a major supplier of raw materials for agro-based industries (Anonymous, 2009). It has been observed that the cultivable land is gradually reducing at the rate of 0.16% due to housing, industries,

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roads, river erosion, etc. As it is an agro-based country, about 80% people live on it. The farmers of Bangladesh are practicing modern and indigenous technologies for increasing crop production. But there are some factors hindering increased crop production.

Some of these factors are limited available technology, lack of irrigation system, inadequate marketing infrastructure, poor access to farm credit, etc. But one of the most important factor is the timely availability of different agricultural inputs, such as; seeds, fertilizers, credit, irrigation, pesticides, etc. at proper time and season to the farmers. Delay of getting or sometimes not getting of some agricultural inputs causes reduction of the average yield. Scarcity and low supply of fertilizer, inadequate amount of quality seeds and unavailability of labors, etc. at the critical period of the crops make the situation very complex. So, timely availability of the agricultural inputs are essential for higher crop production. Thus, the present study was undertaken to find out the real situation and the impact of timely availability of the agricultural inputs on crop production. Therefore, the objectives of the study were:

i) To know the sources of availability of the agricultural inputs;
ii) To know whether the agricultural inputs are available in time or not;
iii) To identify the reasons for not getting the agricultural inputs timely; and
iv) To provide a set of suitable solution on the basis of the findings for getting timely agricultural inputs.

Materials and Methods

Sample survey method was followed to conduct the study. Data were collected from the head of the households (farmers) of the sample village Dhigalgaon in April 2013. To conduct the study, the following steps were followed:

a. Selection of the study area

Dhigalgaon village under Comilla district was selected to have a representative sample for the study. The village is to the east and 3 km from BARD Campus. The total population of this village is 1178 and total number of household is 151. Literacy rate of this village is also 80%.

b. Determination of sample size

Thirty farmers (head of the households) were selected randomly from the same village.

c. Sampling technique

Randomly stratified sampling technique was used during the collection of the information.

d. Methods of data collection

All respondent farmers were invited individually for face-to-face interview. Primary data from the respondent farmers was collected through administering pre-tested questionnaire. Secondary sources of data were also collected to compare the trend and to have some supportive information in different aspects.

Results and Discussion

A. Socio-economic and demographic information

Age of the respondents

Age is considered very important, because young farmers do more in agricultural works than the older one. The mean age of the respondents was 42. It revealed that 50% of the farmers belonged to the age group of 36-50 and 10% belonged to the age group of less than 20 (Table 1).

Table 1. Percentage of the respondents according to their age

Sl. no.	Age (years)	Frequency (n)	Percentage
1	<20	3	10
2	(21-35)	7	22
3	(36-50)	15	50
4	(>50)	5	18
	Total	30	100

Level of education

Education is the backbone of a nation. There are various government and non-government organizations contributing for increasing the literacy rate. The level of education of the farmers varied widely. It revealed about 80% of the farmers were literate and 53% belonged to the group of primary level education. Only 17% of farmers were illiterate (Table 2). This is obviously a good sign of that village.

Table 2. Percentage distribution of the respondents by their level of education

Sl. no.	Level of education	Frequency	Percentage
1	Illiterate	5	17
2	Primary (1-5)	16	53
3	Secondary (6-10)	4	13
4	Higher secondary (11-12)	3	10
5	Higher degree (>12)	2	07
	Total	30	100

Occupation of the respondents

It was found that 60% of the farmers were involved in agriculture and 17% were involved both in agriculture and service, and the rest of the respondents were involved in both agriculture and business (Table 3).

Table 3. Percentage distribution of the respondents according to their occupation

Sl. no.	Categories of the farmers	Frequency	Percentage
1	Agriculture	18	60
2	Agriculture + Service	5	17
3	Agriculture + Business	7	23
	Total	30	100

Income distribution

Income of a family is an important factor to determine the standard of living. It is very difficult to measure actual income because farmers may have different dimensional sources of income, which are not recorded regularly by them. It was found from the study that low, medium and high income category of farmers were 40%, 50% and 10%, respectively. The high income farmers had annual income of Tk. 40,000/= and above (Table 4).

Table 4. Annual income distribution pattern of the farmers

Sl. no.	Categories of the farmers	Frequency	Percentage
1	Low income (<20000 Tk)	8	40
2	Medium income (20001-40000 Tk)	18	50
3	High income (40001 Tk)	4	10
	Total	30	100

Involvement of farmers with NGOs

Involvement of farmers with NGOs is a common phenomenon in the villages of Bangladesh. Some of the farmers of the village were involved with different NGOs; 47% of the respondents were involved with one NGO and 10% of them had link with more than one NGO (Table 5).

Table 5. Percentage distribution of the farmers involved with NGOs

Sl. no.	Categories of the farmers	Frequency	Percentage
1	No involvement	13	43
2	Involvement with one NGO	14	47
3	Involvement with more than one NGO	3	10
	Total	30	100

Farmers' involvement with cooperatives

It was revealed that about 83% of the farmers were involved with Dhigalgaon Shervic Gram Unnayan Somabai Somity (CVDP) and 17% of the farmers had no involvement with NGOs (Table 6).

Table 6. Percentage distribution of the farmer's involvement with cooperatives

Sl. no.	Categories of the farmers	Frequency	Percentage
1	No involvement	5	17
2	Involvement with cooperatives	25	83
	Total	30	100

Receiving credit

From the study it was observed that 61% of the farmers received credit from different sources or organizations and 39% of them had not taken any credit.

Table 7. Percentage of the farmers receiving any credit

Sl. no.	Categories of the farmers	Frequency	Percentage
1	Not received	10	39
2	Received	20	61
	Total	30	100

Participation in training

It was revealed that 66% farmers of the village received agro-based training and 34% farmers were far away from training. They received the highest number of training from BARD, Upazilla DAE, etc. on goat raring, fish cultivation, crop cultivation, etc. But they were found very much interested to receive training on income generating activities.

Table 8. Percentage of the farmers receiving training

Sl. no.	Categories of the farmers	Frequency	Percentage
1	Not received	9	34
2	Received	21	66
	Total	30	100

Pattern of land ownership

The average land ownership of the farmers was 2.2 acres. The marginal farmers possessed the highest (47%) while the large farmers possessed the lowest (7%) acreage of land (Table 9).

Table 9. Pattern of land ownership of the respondents

Land ownership category (acre)	Frequency	Percentage	Percentage of land owned	
			Cultivable land	Non-cultivable land
Landless <0.5	7	23	-	-
Marginal (0.5-2.49)	14	47	75	25
Medium (2.5-7.49)	7	23	80	20
Large (7.50+)	2	7	76	24
Total	30	100	-	-

B. Sources and timely availability of the agricultural inputs

Sources of plough

From the study, it was found that all the farmers (100%) of the village used tractor and power tiller (PT) as a source of plough (Table10).

Table 10. Percentage of the farmers based on sources of plough

Sl. no.	Sources of plough	Frequency	Percentage
1	Bullock	0	0
2	Tractor/Power tiller	30	100
3	Both	0	0
	Total	30	100

Timely availability and getting of plough

Data from Table 11 indicated that 75% of the farmers hired tractor for ploughing their lands. About 25% of them also opined that sometimes availability of tractor was delayed.

Table 11. Percentage of the farmers based on the availability and getting of plough

Sl. no.	Sources of plough	Timely available (%)	Delay in availability (%)	Not at all (%)	Total (%)
1	Tractor/PT	75	25	-	100

Sources of seeds

The farmers of the village were found to grown rice, different kinds of vegetables, such as; sweet gourd, corolla, ladies finger, bitter gourd, brinjal, tomato, lal shak, kalmi shak, etc. but not wheat and jute. It was found that 80% of the farmers used their own seeds of rice during the Aman season and only 4% collected seeds from the dealers. In case of vegetables, 82% farmers used their own seeds. They normally did not buy seeds from BRAC, BADC, etc. due to high price. The result, thus, revealed that majority of the farmers used seeds from their own sources.

Table 12. Percentage of the farmers using the sources of seeds

Sl. no.	Sources	Name of the crops (%)			
		Rice	Wheat	Jute	Vegetables
1	Own	80	-	-	82
2	Neighbors	8	-	-	10
3	Local markets	8	-	-	8
4	Seed dealers/BADC, etc.	4	-	-	-
	Total	100	-	-	100

Timely availability and getting of seeds

It was clear from the study that 78% of farmers could buy their seeds timely and 22% of them bought at late due to delay in availability of seeds (Table 13).

Table 13. Percentage of the farmers based on timely availability and getting of seeds

Sl. no.	Availability	Frequency	Percentage
1	Timely available	23	78
2	Delay in availability	7	22
3	Not at all	-	-
	Total	30	100

Sources of the fertilizers

Fertilizer is an essential agricultural input for crop production. There are two kinds of fertilizers; namely organic manure and chemical fertilizers. About 80% of the farmers used the organic manure from their own sources and only 20% bought from neighbors. In case of chemical fertilizers, 92% of the farmers used to buy from the local markets and only 8% used to buy from the dealers (Table 14).

Table 14. Percentage of the farmers based on sources of the fertilizers

Sl. no.	Sources of fertilizers	Organic manure (%)	Fertilizer
1	Own	80	-
2	Neighbors	20	-
3	Local markets	-	92
4	Dealers	-	8
	Total	100	100

Timely availability and getting of fertilizers

Timely availability of fertilizers and application of these are crucial for crop cultivation. The study indicated that timely availability of organic manure and chemical fertilizers were 83% and 73%, respectively. About 17% and 27% of the farmers opined that yield of crops normally reduced due to delay in availability of organic manure and chemical fertilizers (Table 15).

Table 15. Percentage of the farmers based on availability and timely getting of fertilizers

Sl. no.	Availability	Frequency		Percentage	
		Organic manure	Chemical fertilizers	Organic manure	Chemical fertilizers
1	Timely available	25	22	83	73
2	Delay in availability	5	8	17	27
3	Not at all	-	-	-	-
	Total	30	30	100	100

Sources of irrigation water

The farmers normally used Deep Tube Well (DTW) and Shallow Tube Well (STW) as a source of irrigation. It was revealed that 51% of the farmers used their own sources of irrigation by DTW and 9% of the farmers used irrigation water by STW but both were bought from Somabai Somity (Table 16).

Table 16. Percentage of the farmers based on sources of the irrigation water

Sl. no.	Sources		Frequency		Percentage	
1	Buy	DTW	16	4	51	13
2		STW	2	8	9	27
	Total		30		100	

Timely availability and getting of irrigation water

In case of buying irrigation water, 90% of the farmers could buy irrigation water timely and 10% of them could buy irrigation water at late due to delay in availability (Table 17). Howlader (1996) reported that Bangladesh could achieve self-sufficiency in food by balanced fertilizer use supported by better farm practices and irrigation management.

Table 17. Percentage of the farmers based on availability and timely getting of irrigation water

Sl. no.	Availability	Frequency (n)	Percentage
1	Timely available	27	90
2	Delay in availability	3	10
3	Not at all	-	-
	Total	30	100

Source of the labors

Farmers of the village were mostly marginal. So, about 14% of them worked in the field by their own, 56% depended on wage-labor and 30% used both the sources (Table18).

Table 18. Percentage of the farmers based on sources of the labor

Sl. no.	Sources of labor	Frequency (n)	Percentage
1	Own	4	14
2	Based on wages	17	56
3	Both	9	30
	Total	30	100

Timely availability and getting of labor

In case of wage-based labor, about 70% of the farmers got the labors in time and 30% of them did not get labor timely due to unavailability (Table 19). Moreover, they opined that most of the labors went outside and worked in the industry, factory, etc. where they could earn more money.

Table 19. Percentage of the farmers based on availability and timely getting of labor

Sl. no.	Availability	Frequency (n)	Percentage
1	Timely available	21	70
2	Delay in availability	9	30
3	Not at all	-	-
	Total	30	100

Sources of getting pesticides

Insect and disease infestation to crops is almost a common incidence. Many often farmers faced severe problems due to these incidence. For this, they had no other alternatives of using pesticides to control insects and diseases. It was found that 87% of the farmers collected pesticides from the local markets and only 13% of them collected from dealers (Table 20).

Table 20. Percentage of farmers based on sources of getting pesticides

Sl. no.	Sources	Frequency (n)	Percentage
1	Local markets	26	87
2	Dealers	4	13
3	Others	-	-
	Total	30	100

Timely availability and getting of pesticides

As shown in Table 21, 90% of the farmers timely got the pesticides from the markets and 10% of them did not get timely due to unavailability or lack of desired pesticides. Moreover, the price of the desired pesticides was not found too high than the real.

Table 21. Percentage of the farmers based on availability and timely getting of pesticides

Sl. no.	Availability	Frequency (n)	Percentage
1	Timely available	27	90
2	Delay in availability	3	10
3	Not at all	-	-
	Total	30	100

Impact of timely availability of agricultural inputs on crop production

From the study it reveals that if the agricultural inputs are available in time and farmers can apply to crops at the appropriate time, production of the crops can be substantially increased. On the other hand, if the inputs are not timely available, production will be drastically decreased.

Table 22. Percentage of the farmers based on impact of timely availability of the agricultural inputs on crop production

Sl. no.	Availability	Frequency	Production increased (%)	Production decreased (%)
1	Timely available	30	100	-
2	Delay in availability	30	-	100

Conclusion

From the case study, it revealed that the farmers of the Dhigalgaon village did not get the required amount of agricultural inputs in time which seriously hampered the crop production and this is the common scenario of Bangladesh. So, government should take necessary steps to make availability of all the agricultural inputs to sustain crop production of the country.

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DEVELOPMENT OF A GRAPHICAL USER INTERFACE BASED RADIATION MONITORING SYSTEM

K. S. Arefin, M. M. H. Sohag and S. H. Bhuiya

Abstract

Considering hardware independence and cost effectiveness, a radiation area monitoring system was developed using a very common Geiger-Mueller counter, a micro controller and LabVIEW virtual instrumentation (VI). The performance of the system was compared with a calibrated survey meter at real irradiation facility. Using the gamma irradiation facility of the Bangladesh Institute of Nuclear Agriculture (BINA), the dose equivalent rate was measured at different distances and positions by the developed radiation monitor. The measured data was also compared with measured data of the existing survey meter RAM R-200, which was calibrated in the Institute of Nuclear Science and Technology, AERE, Savar, Dhaka. The measured data was found to be almost similar to the RAM R-200. Thus, it was concluded that the developed graphical interface based radiation monitoring system could be used for the application of area monitoring with accuracy.

Key words: Dose equivalent rate, Radiation area monitor, Virtual instrumentation

Introduction

Radioactive materials are used in environmental monitoring, diagnostic and therapeutic medical procedures, aerospace, military applications and agriculture, such as; mutation breeding, soil and water study, food irradiation, etc. Ionizing radiation from these radio active materials or from different irradiation facilities could cause accidents and serious health risks in the proximity of these radiation sources. Peaceful use of nuclear energy needs sound monitoring system. It is also a pre-condition to keep the dose rate at a permissible label for radiation worker (Anonymous, 2004). Workplace Monitoring for radiation and contamination is of great importance and necessitates the use of sensitive, accurate and calibrated devices for these functions (Anonymous, 2000). Different survey meters are available in the market but those are fixed hardware and not possible to moderate or upgrade by the user. These survey meters are not even possible to repair in many cases. Most of the cases, it cannot attach with a computer for data acquisition. By the use of open source micro controller and virtual instrumentation (LabVIEW) for digital signal processing (DSP),

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customize hardware based nuclear instruments were developed by the scientists for their customize operation and time to time modification. DSP is used in all engineering areas, such as; in nuclear physics experiments, in order to replace conventional analog systems and build measurement and test systems with an easy configuration, user-friendly interface and possibility to run sophisticated experiments. DSP systems are applied in nuclear physics experiments for their performance in both energy and time domain.

A virtual instrument consists of an industry-standard computer or workstation equipped with powerful application software and cost-effective hardware, such as; plug-in boards and driver software, which together perform the functions of traditional instruments. Virtual instruments represent a fundamental shift from traditional hardware-centered instrumentation systems to software-centered systems that exploit the computing power, productivity, display and connectivity capabilities of popular desktop computers and workstations. Although the PC and integrated circuit technology have experienced significant advances in the last two decades, it is the software that truly provides the leverage to build on this powerful hardware foundation to create virtual instruments, providing better ways to innovate and significantly reduce cost. With virtual instruments, engineers and scientists build measurement and automation systems that suit their needs exactly (user-defined) instead of being limited by traditional fixed-function instruments (vendor-defined).

Virtual instrumentation is used in γ-ray intensity analyzer for data analysis and presentation (Tlaczala, 2005). Advanced nuclear physics experiments and measurements are presented by simulated nuclear physics experiments (Tlaczala *et al*., 2008). Digital acquisition system is used to acquire data from n-γ detectors (Belli *et al*., 2008). The virtual instrumentation technique has been applied to develop a system which provides nuclear spectroscopic measurements, such as; amplitude and time signal analysis (Pechousek *et al*., 2011). So, the use of virtual instrumentation is a well established process for digital signal processing and data acquisition. The new way in the design of computer-based measurement systems can be seen in the use of up-to-date measurement, control and testing systems based on reliable devices. Now-a-day, nuclear DSP systems are commonly realized by the virtual instrumentation technique performed in LabVIEW (National Instruments, 2004) graphical programming environment. The advantages of this approach lie in the use of (a) ready-to-start measurement functions (DSP algorithms) (b) instrument drivers delivered with measurement devices and (c) in the possibility to improve a particular system when new algorithms, drivers or devices are available. With these opportunities, a system using these techniques and based on commercially available devices (USB, PCI, PXI, etc.) can be driven by any suitable developed application. This application is then nearly "hardware platform independent". Many papers concerning nuclear physics experiments have been published so far and in many of them, LabVIEW has been successfully applied. It can be mentioned the development of a computer-based nuclear radiation detection and instrumentation teaching laboratory system (Ellis & He, 1993), where the sophisticated setup of various devices is presented. Simulation and analysis of nuclear instrumentation using the LabVIEW was performed by Abdel-Aal (1993). Versatile pc-based gamma ray monitor for laboratory and field measurement was developed by V Drndarevic and Jevtic (2007).

In this article virtual instrumentation based design of a hardware-independent and cost-effective radiation monitor was presented.

Materials and Methods

In this system, the Geiger tube with GCK 05 was used to generate a TTL logic pulse for the detection of radioactive particles continuously. This pulse was counted and measured for unit time by a micro controller (Arduino) and then was fed to computer where graphical user interface software was built to acquire this data and represented it in dose rate. The block diagram of graphical user interface based radiation monitoring system is shown in Fig. 1.

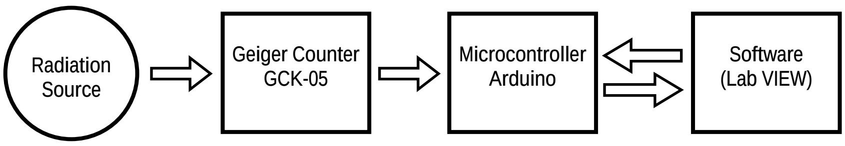

Fig. 1. Graphical User Interface based Radiation Monitoring System

The Geiger Counter kits GCK-05 as shown in Fig. 2, detected radiation energy of above 3MeV, 50 KeV and 7 KeV for alpha, beta and gamma rays, respectively. Each output pulse from the GM tube was a count. The counts per second gave an approximation of the strength of the radiation field. The GM tube's response to a cesium-137 source is shown in Fig. 3. From this response graph a relation was found between the counter rate and dose rate as $mR/h = (Counts/16.274)^{1.061}$ or $\mu Sv/hr = ((Counts/16.274)^{1.061})*0.1$.

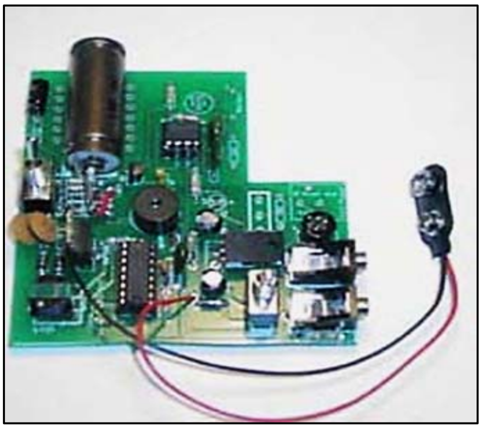

Fig. 2. Analog Geiger Counter GCK-05

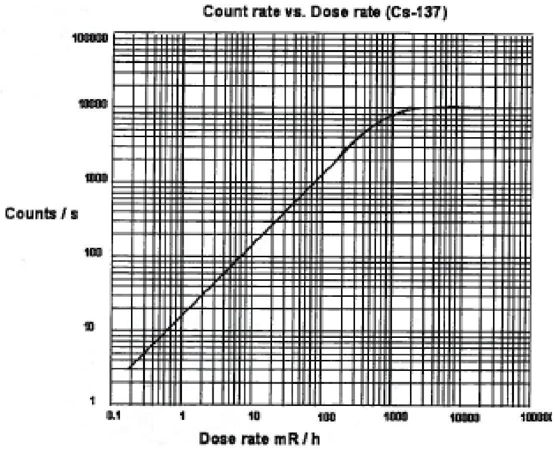

Fig. 3. GM tube response

A programme for Arduino was written so that when a pulse of electricity was generated as radiation passed through the GM tube, this pulse was detected to the micro controller (Fig. 4). It also caused the Arduino to react and count (by attaching an interrupt) that some form of radiation was present. So, from this GM counter, the analog signal of counts was feed to an open source 8-bit microcontroller (based on the ATMEGA328 chip) Arduino where a programme was written to acquire this TTL pulse signal and converted this analog signal to digital one by a 10-bit ADC.

A graphical user interface based application was developed (Fig. 5) by LabVIEW which could run in any system. The block diagram is shown in Fig. 6.

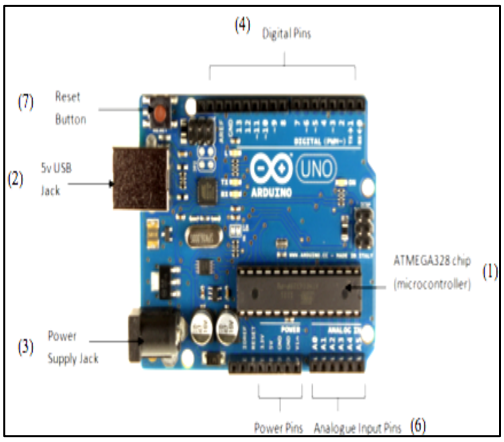

Fig. 4. Labeled photograph of the Arduino UNO

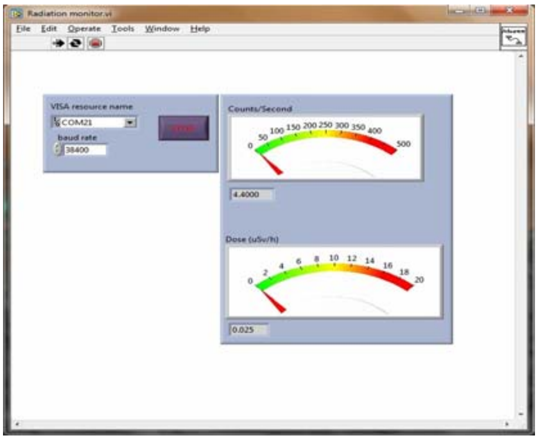

Fig. 5. User Interface of Radiation Monitoring System

A programme was written for micro controller in Arduino and was loaded to this board. Then the board was connected to PC or laptop through USB where the written LabVIEW software communicated with micro controller. A function generator (National Instruments, 2009) with known frequency was connected to the micro controller to test the micro controller and software. After that GCK-05 was connected with Arduino. The performance of this radiation monitoring system was compared with radiation survey meter RAM R-200. This experiment was conducted at the Bangladesh Institute of Nuclear Agriculture (BINA) on 21/01/2014 where the reading was taken at different distances and positions from Gamma Chamber (GC-5000) manufactured by BRIT, India (10473 Ci on 13-09-2012). The sources were cobalt-60 stationary source pencils and those were symmetrically placed in a cylindrical cage. Area monitoring readings (Equivalent dose in µSv/hr) were taken at surface, 0.5 m, 1 m and 2 m from front side of GC-5000 and at surface, 0.5 m and 1 m from back side of the source.

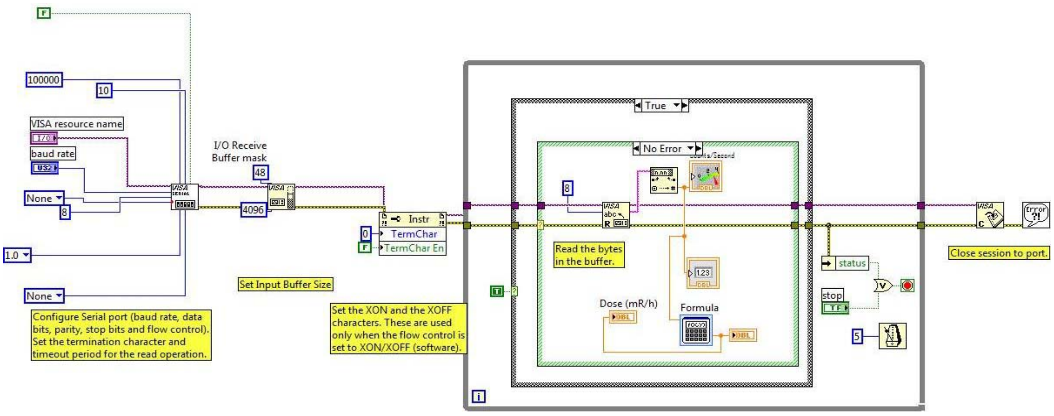

Fig. 6. Block diagram of Radiation monitoring Application

Results and Discussion

It was found that for known frequency signal from function generator to micro controller input, the same count showed at LabVIEW graphical user interface (software). It was also tested by a counter for different count rate and it could count the number of pulses.

The result of comparison of the system with other radiation survey meter is shown in Fig. 7 for front side of the source (GC-5000) and in Fig. 8 for back side of that source. Radiation at front side of the GC-5000 was measured by the system as 2.61, 1.80, 1.02 and 0.64 µSv/hr for surface, 0.5 m, 1 m and 2 m distances, respectively.

Radiation measured by calibrated survey meter were 2.75, 1.73, 0.97 and 0.72 μSv/hr for surface, 0.5 m, 1 m and 2 m distances, respectively. At the back side of the GC-5000, radiation measured by the system were 2.39, 1.73, 1.49 μSv/hr for surface, 0.5 m and 1 m, respectively and by the calibrated survey meter were 2.26, 1.66 and 1.34 μSv/hr for surface, 0.5 m and 1 m, respectively. Differences between the two meters measurement were ± 5% which was acceptable rage (Anonymous, 2004).

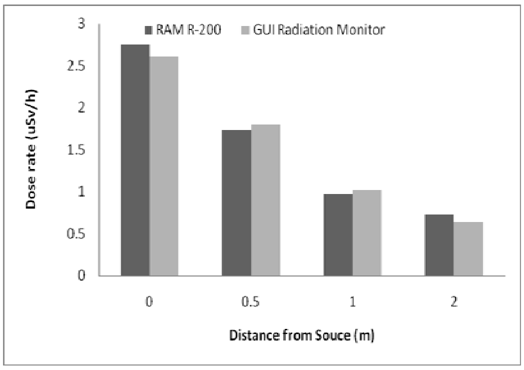

Fig. 7. Radiation at front side of the Gamma Chamber 5000

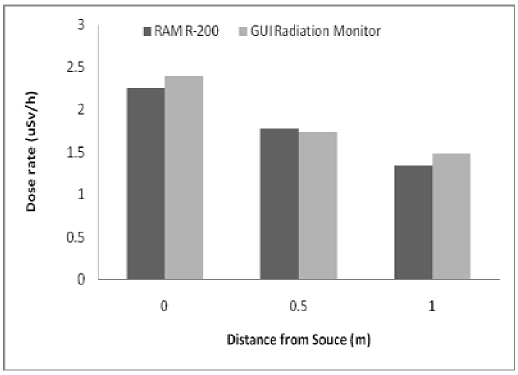

Fig. 8. Radiation at back side of the Gamma Chamber 5000

Conclusion

The constructed radiation detection and measurement system could be used as a useful area monitoring device. Being a low cost micro controller and Geiger counter kit, the system would be a viable cheaper alternative to the existing Gamma radiation survey meters. It's less hardware dependency also might make it easy to upgrade. A high performance GM tube and large ADC based micro controller for data acquisition (Esposito, 2007) might be possible to attach with this system for wide range area monitoring with better precession.

Acknowledgements

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NEED FOR CAPACITY STRENGTHENING OF RURAL WOMEN IN CONDUCTING POST-HARVEST ACTIVITIES OF POTATO

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Abstract

The main objective of this study was to determine the extent of need for capacity strengthening of women in conducting post-harvest activities of potato. Besides the main focus, the extent of involvement in post-harvest activities of women was identified and relationships of the selected characteristics of the women were explored with their extent of need for capacity strengthening. The study was conducted with the six groups of women (total 60) of NCDP (North West Crop Diversification Project) of three villages of Khetlal Upazila under Joypurhut district. A pre-tested interview schedule was used to collect data from the respondents during March and April 2009. Need for capacity strengthening of women was the dependent variable and the ten selected characteristics of the respondents constituted the independent variables of the study. Pearson's Product Moment Correlation Co-efficient (r) was computed to explore the relationship of the characteristics of the respondents with their extent of need for capacity strengthening. The average involvement of rural women in post-harvest activities of potato was 26.13 percent and all the respondents were involved (low to medium) in post-harvest activities of potato. The women had the highest extent (79.33 percent) of need for capacity strengthening for physical facilities and the lowest extent (66 percent) of need was for capacity strengthening in management skill. Among the characteristics of the respondents, credit received and ability to cope with uncertinity showed significant negative relationship; and organizational participation and decision making capacity in the family showed significant positive relationship with their extent of need for capacity strengthening in conducting post-harvest activities of potato. Education, dependency ratio of the family, farm size, annual family income and training exposure did not show any significant relationship with their extent of need for capacity strengthening in conducting post-harvest activities of potato. The root causes of low involvement in post-harvest activities of potato were lack of training on post-harvest activities, cold storage, processing equipments, marketing facilities and social/religious barrier. The result revealed that increased training facilities according to their needs for increasing their knowledge and skill for conducting post-harvest activities of potato can over could the situation.

Key words: Capacity strangthaing, Post-harvest, Rural women

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Introduction

Bangladesh is the most over populated and impoverished country in the world and it is a home to an estimated 140 plus million people. Women in rural Bangladesh are major but largely unrecognized contributors to agricultural and economic productivity. Half of these human resources consists of women and the majority of them live in the rural areas (Islam, 2004). Women in Bangladesh are mostly responsible for grain processing and storage. They grow most of the family's fruits and vegetables, and participate in post-harvest activities. Today, potato is the fourth most important food crop in the world, with an annual production approaching 300 million tons (Anonymous, 2007). It is considered as a staple food in many countries of the world (Mc Laughlin *et al.,* 1994), but in Bangladesh, it is considered as a vegetable crop (Ahmad, 1977). The potato ranks first among the vegetables grown in Bangladesh, both in area and production (Anonymous, 2000). It contributes alone as much as 63 percent of the total annual vegetable production in Bangladesh, and its production per unit area is more than rice and wheat (Ahmad, 1977; BBS, 2004). In 2004-2005, potato was grown in an area of 3,01,000 ha and its production was 3.386 million metric tons (Anonymous, 2006). The average yield of potato in our country is 13.81 tons/ha (Anonymous, 2003), which is much lower than that of many potato growing countries of the world. Proper methods of processing, storage, bagging, transport and marketing are required to fulfill the demand of potato crop. One of the attributes to this post-harvest system is the large amount of its wastage. In Bangladesh, the post-harvest losses of potato is 20 percent. The losses occur during the operation of handling, transportation, field stacking, threshing and storage. About 75 percent of the potato are stored at home and remaining 25 percent are stored in the cold storage (Mazed, 2004). Potato are produced in north-western part of Bangladesh, specially in Joypurhat, Rangpur and Dinajpur district of which about 35-38 percent post-harvest losses are caused due to inefficient handling during transportation, storage and marketing (Rubbi *et al.*, 1986). According to other reports, post-harvest losses of potato in Joypurhat district is around 27.16 percent (Azad, 2001). The production of potato in greater Joypurhat district was 93245 metric tones in 2004 (Anonymous, 2005) with an average loss of 27.16 percent.

Women's involvement in post-harvest facilities, such as; cold storage, processing equipments, grading and packaging materials, proper marketing channel, vehicles, sales centers, etc. must be provided if it is aimed to increase the contribution of potato in the national economy.

Capacity strengthening of women in conducting post-harvest activities of potato is the extent to which they have the accessibility to financial, physical and managerial support services as well as the ability to make decision about utilizing the post-harvest activities of potato. Therefore, their capacity of handling post-harvest activities need to be improved. So, the present study was designed;

(a) to find out the extent of involvement of women in conducting post-harvest activities of potato;
(b) to find out the need for capacity strengthening of women in conducting post-harvest activities of potato;
(c) to explore the relationships of some selected characteristics of the women with their need for capacity strengthening in conducting post-harvest activities; and
(d) to find out the problems of low involvement of women in the post-harvest activities of potato.

Materials and Methods

Field works of the investigation were carried out at Kusumsahar in Khetlal Upazila of Joypurhat District. The main concern of this research was for capacity strengthening of women in conducting post-harvest activities of potato. Khetlal upazila is famous for potato production. Considering the limited scope, resource and time of the study, 230 population from one study area (Kusumsahar village) was selected. Women engaged in post-harvest activities of potato were selected randomly for data collection through personal interview. The interviews were conducted with the respondents individually in their respective houses or house premises. Wherever the respondents felt any difficulty in understanding any questions, utmost care was taken to explain and clarify the same properly.

Results and Discussion

Involvement score of the respondents in different post-harvest activities ranged from 13.00 to 47.00 with a mean of 26.13 and standard deviation of 6.85 (Table 1). On the basis of the involvement, the respondents were divided into three categories.

Table 1. Distribution of the respondents according to their involvement in post-harvest activities of potato

Respondents			Mean	Standard deviation
Categories	Number	Percent		
Low (≤ 33)	47	78.3		
Medium (34-66)	13	21.7	26.13	6.85
High (>66)	0	0		

The involvement of rural women was measured in three dimensions, such as; frequency of performance, part of work done and control over decision. Each of these three dimensions also had five sub-dimensions with a score of 0 to 3. Most of the respondents were involved in post-harvest activities; like sorting and grading, seed storage, processing, packaging, and insect and disease control, etc. The activities are presented in the Table 2.

Table 2. Ranking of total score of involvement of rural women in different post-harvest activities of potato

Post-harvest activities	Frequency of performance	Part of work done	Control over decision	Total score	Rank order
Sorting and grading	130	127	90	347	1
Seed storage	108	83	37	228	2
Storage potato	110	65	32	207	3
Processing	66	70	69	205	4
Packaging	93	83	19	195	5
Insect and disease control	85	68	27	180	6

Characteristics of the rural women

There were various characteristics of the rural women that influenced their extent of need for capacity strengthening in conducting post-harvest activities of potato. In the present study, ten characteristics of the rural women were selected as; independent variables, which included age, education, dependency ratio of the family, farm size, annual family income, organizational participation, decision making capacity in the family, daily time allocation, training exposure, credit received and ability to cope with uncertainty. The characteristics of the respondents are presented in the Table 3.

Table 3. Personal characteristics of the women involved in different post-harvest activities of potato

Characteristics (Measurement units)	Range		Respondent			Mean	Std. Dev.
	Possible	Observed	Category	No.	%		
Age (year)	-	18-62	Young (≤30) Middle aged(31-45) Old (>45)	28 25 7	46.7 41.6 11.7	35.60	11.29
Education (year of schooling)	-	0-12	Illiterate (0) Primary (1-5) Secondary (6-10) Higher secondary (>10)	11 27 20 2	18.3 45.0 33.4 3.3	4.36	3.93

Table 3. Contd.

Characteristics (Measurement units)	Range		Respondent			Mean	Std. Dev.
	Possible	Observed	Category	No.	%		
Dependency ratio of the family (ratio)	-	0-5	Low (≤2) Medium (2.1-4) High (>4)	40 18 2	66.7 30.0 3.3	2.12	1.26
Family farm size (hectare)	-	.01-3.92	Landless (< 0.02) Marginal (.021-.2) Small (0.21-1.0) Medium (1.1-3.0) Large (>3.0)	1 10 24 24 1	1.7 16.6 40.0 40.0 1.7	0.84	0.74
Annual family income (‘000’Tk.)	-	2.00-662.5	Low (≤50) Medium (50.1-100) High (>100)	6 10 44	10.0 16.7 73.3	90.7	34.84
Organizational participation	-	0-5	Low (≤2) Moderate (3-4) High (>4)	50 9 1	83.3 10.0 6.7	0.80	1.25
Decision making capacity in the family (score)	0-40	10-23	Weak (≤13) Moderate (14-26) Strong (>26)	27 31 2	45.0 51.7 3.3	14.80	5.15
Training exposure (score)	-	0-60	Null (0) Short-term (1-3) Mid-term (>3)	41 11 8	68.3 18.4 13.3	2.72	9.28
Credit received (‘000’ Taka.)	-	0-50	Small (≤10) Medium (11-20) High (>20)	45 7 8	75.0 11.7 13.3	8.86	12.08
Ability to cope with uncertainty (score)	0-24	7-21	Low (≤8) Moderate (9-16) Strong (>16)	29 22 9	48.3 36.7 15.0	12.06	4.51

Need for capacity strengthening of rural women

Need for capacity strengthening of women was the main focus of the present research work. Five dimensions of capacity strengthening were selected to measure the extent of need for capacity strengthening of women. The findings are presented in the following subsections.

1. Overall need for capacity strengthening

The extent of need for capacity strengthening of women was assessed in terms of need index for capacity strengthening (NICS) are shown in Table 4.

Table 4. Need for capacity strengthening of women in conducting post-harvest activities of potato

Categories	Respondents No.	Respondents %	Mean	Std. Dev.
Low need (≤33)	0	0		
Medium need(34-66)	12	20	73.60	11.63
High need (>66)	48	80		

Score Range: *Possible: 0-100, Observed: 44.44-98.77*

The findings clearly indicated that most of the respondents had high need for capacity strengthening in conducting post-harvest activities of potato.

2. Dimension-wise need for capacity strengthening of rural women

Five dimensions of capacity strengthening were selected to assess the extent of need for capacity strengthening of women in conducting post-harvest activities of potato. The computed NICS values of all the dimensions are shown in Table 5.

Table 5. Dimension-wise need for capacity strengthening of women in conducting post-harvest activities of potato

Dimensions (measuring unit)	Range Possible	Range Observed	Respondents Categories	No.	%	Mean	Std. Dev.
Need for financial ability (%)	0-100	50-100	Low (≤33)	0	0	79.33	15.08
			Medium (34-66)	10	16.7		
			High (>66)	50	83.3		
Need for decision making ability (%)	0-100	38.89-100	Low (≤33)	0	0	66.00	12.23
			Medium (34-66)	27	45		
			High (>66)	33	55		
Need for access to support services (%)	0-100	50-100	Low (≤33)	0	0	73.33	12.65
			Medium (33-66)	10	16.7		
			High (>66)	50	83.3		
Need for management skill (%)	0-100	22.22-100	Low (≤33)	1	1.7	77.22	15.72
			Medium (34-66)	6	10.0		
			High (>66)	53	88.3		
Need for physical facilities (%)	0-100	.00-100	Low (≤33)	1	1.7	74.13	17.02
			Medium (34-66)	6	10.0		
			High (>66)	53	88.3		

It might be worthy to mention here that the differences among the components of need for capacity strengthening in conducting post-harvest activities of potato were not significant, as shown in Figure 1.

Women were mostly involved in post-harvest activities of potatoes but due to their physical and social barrier, they were not fully involved in all the activities, like transportation and marketing.

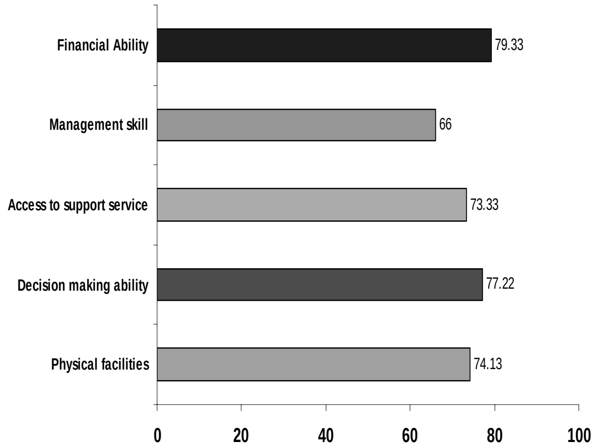

Figure 1. Need status of the respondents

Relationships between the selected characteristics of the rural women and their extent of need for capacity strengthening

The relationship between the dependent and independent variables are presented in Table 6.

Table 6. Relationship between the dependent and independent variables

Independent variables	'r' value with 58 df
Age	-.248
Education	.147
Dependency ratio of the family	-.240
Farm size	.070
Annual family income	-.107
Organizational participation	.404 **
Decision making capacity in the family	.368 **
Training exposure	.038
Credit received	-.281*
Ability to cope with uncertainty	-.291*

** Significant at the 0.01 leve, * Significant at the 0.05 level

Problems towards low involvement in post-harvest activities of potato

Problems faced by the women in using post-harvest activities of potato were measured through conducing Scored Causal Diagrams (SCDs) of Participatory Rural Management, as shown in Figure 2.

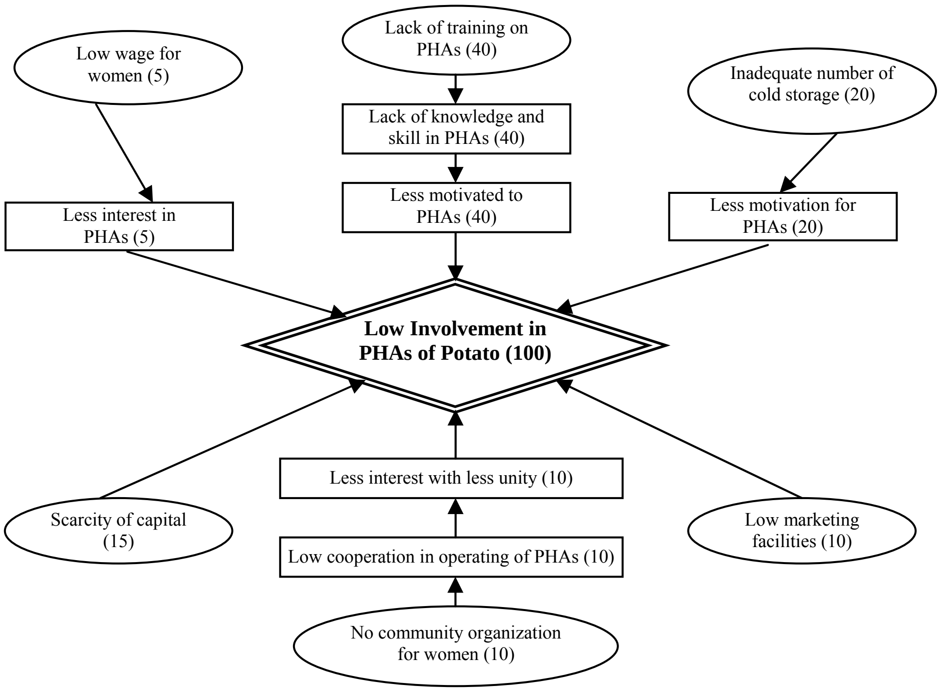

Figure 2. Scored Causal Diagrams showing the involvement barrier of rural women in PHAs of potato

Suggested solutions to the 'root' causes

Participants of the group engaged in the preparation of Scored Causal Diagram (SCD) were requested to mention possible solutions to the 'root' causes of low involvement in the post-harvest activities of potato. The respondents expressed different opinions on how these problems could be solved. The suggestions for the solution of the problems made by the respondent women are given in Table 7.

Involvement of the rural women in post-harvest activities is an important issue for controlling post-harvest activities and development of socio-economic condition of the rural people. The study revealed that involvement of the rural women in post-harvest activities was medium to high, which is encouraging. Thus, proper strategy and need-based support should be ensured in order to secure full involvement of the rural women in post-harvest activities. Linkage between GOs and NGOs need to be strengthened to ensure effective involvement of the rural women. The issues that might be dealt with are input and technical information supply, training, motivation campaign and others.

Table 7 Suggested solutions with ways to achieve them

Sl. no.	Suggested solutions	Ways to achieve
1.	Increased training facilities according to their needs for increasing their knowledge and skill in conducting post-harvest activities of potato as well as to have efficient manpower.	Need GOs and NGOs collaboration
2.	Involving rural women in different post-harvest activities of potato to increase their operational ability.	Government and private organizations should take initiatives
3.	Establishing processing centers for the rural women to build their capacity in post-harvest activities.	Government can create special programs with the well known NGOs
4.	Emphasizing the necessities of women involvement among the rural people with the help of local leaders, *imams*, *purohit*, etc.	Farmers should be motivated to aware the women by different communication media
5.	Establishing cold storage for the rural women by the government.	Government can take proper initiatives
6.	Increased credit availability according to the need of the rural women regarding post-harvest facilities of potato.	GOs and NGOs can take proper steps in this matter

Conclusion

Findings of the study and the logical interpretations of their meanings in the light of other relevant facts prompted the researcher to draw the following conclusions:

- The findings indicated that most of the respondents (80 percent) had high extent of need for capacity strengthening. So, there is enough scope to provide facilities regarding post-harvest operations of potato which may improve the capacity of the rural women.
- Findings indicated that about 40 percent of the respondents had small farm size. Although this is the general situation of Bangladesh that the farm size is decreasing day by day but it is easy to aware the rural women to build their capacity for proper utilizing their small farm land.

- Most of the rural women (83.3 percent) had low organizational participation and moderate capacity to make decision in the family. Besides, need for capacity strengthening was increased with the increase of organizational participation. Thus, it indicates that in rural areas there are many scopes to involve rural women in different organizations and build their capacity towards practicing post-harvest activities of potato.
- The highest proportion (75 percent) of the women had small credit received. This was due to low organizational participation, because rural women mainly get credit facilities from different NGOs; like Grameen Bank, BRAC, Proshika, etc. However, credit received by the women had significant positive relationship with their need for capacity strengthening in conducting post-harvest activities of potato. So, it is clear that more credit facilities are helpful for strengthening their capacity in conducting post-harvest activities of potato.
- Almost all the respondents had low to medium decision making capacity in the family and this variable had significant negative relationship with their need for capacity strengthening in conducting post-harvest activities of potato. So, women having more capacity to make decision in the family felt less need for capacity strengthening.
- Almost half (48.3 percent) of the respondents had less ability to cope with uncertainty. This characteristic of the women was negatively and significantly correlated with their need for capacity strengthening in conducting post-harvest activities of potato. Thus, the more ability to cope with uncertainty, the less would be the need for capacity strengthening in conducting post-harvest activities of potato.

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STUDIES ON AGRO-CLIMATIC PARAMETERS FOR CROP PLANNING AT THREE LOCATIONS OF SATKHIRA, HATIYA AND MAIZDICOURT

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Abstract

An agro-climatic study was undertaken to investigate the trends of climatic parameters using data from Satkhira, Hatiya and Maizdicourt weather stations. Daily values of maximum temperature, minimum temperature, rainfall and relative humidity from 1973 to 2012 were collected. From the daily data, monthly and annual values were calculated for analysis. Prediction was also carried out by using the "MAKESENS" model for the year of 2020, 2025 and 2030. The results indicated that the trend lines of maximum temperature gradually increased in Hatiya and Maizdicourt, whereas slightly decreased in Satkhira. In contrast, the trend lines of minimum temperature slightly increased at Satkhira, gradually decreased in Hatiya and gradually increased in Maizdicourt. The trend lines of total rainfall were more or less same in Satkhira, but slightly increased in Hatiya, whereas slightly decreased in Maizdicourt. The trend lines of relative humidity increased in the three different stations, but highly increased at Satkhira and Hatiya, whereas slightly increased in Maizdicourt. It was predicted that the trend lines of maximum temperature would be gradually increased in summer season and the minimum temperature would be gradually decreased in winter season for these three selected stations. Again, the trend lines of total rainfall would be increased in rainy season and decreased in summer season. Further, trend lines of relative humidity would be increased in rainy season and decreased in summer season for the three selected stations.

Key words: Agro-climatic parameters, Climate change, Prediction, Trend

Introduction

Bangladesh is an agro-based country. Agriculture sector is the single largest contributor of about 20 percent to the country's GDP (Anonymous, 2010). Cropping intensity in saline area of Bangladesh is relatively low, ranging from 62% in Chittagong coastal region to 114% in Patuakhali coastal region, against the national average cropping intensity of 179% (Anonymous, 2009). Increase in salt water intrusion

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and soil salinity have serious negative impacts on agriculture (Anonymous, 2007), but the magnitude of the yield increase depends on environmental conditions (Lamp and Podder, 1988; Singh and Saxena, 1999). On an average, bout a quarter of the country's landmass is currently flood prone (Anonymous, 2013). Since, agricultural experimentation is expensive and time consuming; the climatological information may help a great deal to consider extrapolation of research results to a particular region, having 'climatic analogues' (Chang, 1981).

The study was undertaken to improve the economy of Bangladesh in terms of its contribution to GDP, employment generation, livelihoods and poverty alleviation. The sector, however, has been under increasing stress due to various natural hazards, including that of climate change. Climate change-induced extreme events, such as; floods, droughts, cyclones, storm surges, sea level rise and salinity intrusion are likely to occur more frequently and to become intensified in the future. This will sharply affect food production, especially in vulnerable areas, such as; the country's low-lying coastal belts. As agriculture is highly vulnerable to climate change, food security, food prices and nutrition will be adversely affected. Therefore, there is a strong need for decision makers to take climate change into account in their development planning, and further explore the synergies between climate change adaptation and agricultural development.

The main objectives of this study were (i) to evaluate long-term trend of agro-climatic parameters (ii) to predict the agro-climatic parameter for the future and (iii) to identify time and area for suitability for crop production.

Materials and Methods

Major climatological data, like maximum temperature, minimum temperature, rainfall, relative humidity for a period of 40-years (1973-2012) were collected for Satkhira, Hatiya and Maizdicourt stations from the Meteorological Department of Bangladesh (MDB) situated at Agargoan, Dhaka. At first, monthly values were calculated from the daily data. Average values of monthly maximum temperature and minimum temperature (^{0}C) for each month of the year were calculated from the 40-years data (1973-2012). Then these values were plotted against the months to see the decade wise variation of monthly maximum temperature over the year for the study stations. Similar diagrams were plotted using average values of monthly minimum temperature (^{0}C) to see the decade wise variation of minimum temperature for the stations. This aided to identify the warmest and coldest months at these three stations. Maximum and Minimum temperature (^{0}C) values were plotted on Excel spread-sheet for the three stations and trend line were fitted through them. From the equations of trend line, the base line values (values represented by the trend lines) of annual mean temperature were calculated at the beginning (1973) and end (2012) of the study period. Monthly and annual rainfall (mm) totals were calculated from the daily rainfall (mm) data for the entire study period. Similar analyses, as mentioned above, were also carried out with the annual and monthly rainfall values. Daily data on relative humidity (%) were available from 1973 to 2012 for all the three stations. From these data, analyses were carried out following the above mentioned method.

Studies on the Trend of Agro-Climatic Parameters

The **“MAKESENS”** software was used to detect and estimate trends. This software is based on the non-parametric Mann-Kendall test for trends and the non-parametric Sen’s method for the magnitude of the trend (Salmi *et al.,* 2002). The advantage of the non-parametric method is that it is applicable for both monotonic and non-monotonic trends, and it can operate with missing data.

The software utilizes S statistics and Z statistics given in Gilbert (1987). For data series with <10, the S test is used and for ≥10, the Z test is used. When the number of data points <10, the test statistics S is computed as:

$$S = \sum_{k=1}^{n-1} \sum_{j=1}^{n} \operatorname{sgn}(xj - xk) \quad \text{......................... (1)}$$

Here, x_j and x_k are the annual values in years j and k, respectively and

$$\operatorname{sgn}(x_j - x_k) = \begin{bmatrix} 1 \; if xj - xk > 0 \\ 0 \; if xj - xk = 0 \\ -1 \; if xj - xk < 0 \end{bmatrix} \quad \text{......................... (2)}$$

A very high positive value of S is an indicator of an increasing trend, and a very low negative value indicates a decreasing trend. However, it is necessary to compute the probability associated with S and the sample size, n, to statistically quantify the significance of the trend. The two-tailed test is used for four different significance levels (α): 0.1, 0.05, 0.01 and 0.001. Details regarding the MAKESENS model can be found in Salmi *et al.* (2002). The agro-climatic parameter conditions are predicted as:

Agro-climatic parameter = B + Q × (Simulation year-Base year)

Where, B is the intercept and Q is the slope of the trend line, which were found from model output. The simulation years were selected as 2020, 2025, and 2030. The base year was 1973 (the first year of the data set).

Results and Discussion

Results of the analyses of climatic data of the selected Satkhira, Hatiya and Maizdicourt meteorological stations are presented and discussed below. Predictions were made for the year of 2020, 2025 and 2030 for crop planning.

Temperature

40-years average values of mean monthly maximum and minimum temperatures for the selected stations are shown in Table 1. The results showed that 38.35^{0}C was the warmest temperature in May (1979) and 10.4^{0}C was the coolest temperature in January (2001) at Satkhira; 33.76^{0}C was the warmest temperature in May (1979) and 11.85^{0}C was the coolest temperature in January (2001) at Hatiya; 34.87^{0}C was the warmest temperature in April (1999) and 11.66^{0}C was the coolest temperature in January (1989) at Maizdicourt.

Long-term pattern of maximum and minimum temperatures are shown in Fig. 1 and Fig. 2, respectively. Five years average of monthly maximum and minimum temperature of the three stations are shown in Fig. 3 and Fig. 4, respectively.

Prediction of maximum temperature and minimum temperature for 2020, 2025 and 2030 are shown in Table 2 and Table 3 for the three stations. The results showed that 35.56^{0}C would be the warmest temperature in May and 12.15^{0}C would be the coolest temperature in January for the year 2020 at Satkhira. Again, 35.36 ^{0}C would be the warmest temperature in May and 12.12^{0}C would be the coolest temperature in January for the year 2025 at Satkhira. On the other hand, 35.67^{0}C would be the warmest temperature in May and 12.10^{0}C would be the coolest temperature in January for the year 2030 at Satkhira.

Similarly, 32.73^{0}C would be the warmest temperature in May and 13.18^{0}C would be the coolest temperature in January for the year 2020 at Hatiya. Again, 32.84^{0}C would be the warmest temperature in May and 12.93 ^{0}C would be the coolest temperature in January for the year 2025 at Hatiya. On the other hand, 34.77 ^{0}C would be the warmest temperature in May and 12.69^{0}C would be the coolest temperature in January for the year 2030 at Hatiya.

Similarly, 34.77^{0}C would be the warmest temperature in May and 14.67^{0}C would be the coolest temperature in January for the year 2020 at Maizdicourt. Again, 35.16^{0}C would be the warmest temperature in May and 14.57^{0}C would be the coolest temperature in January for the year 2025 at Maizdicourt. Further, 35.67^{0}C would be the warmest temperature in April and 14.63^{0}C would be the coolest temperature in January for the year 2030 at Maizdicourt.

Rainfall

40-years average values of total monthly maximum and minimum rainfall for the three stations are shown in Table. 1. The results showed that 696 mm was the maximum rainfall in September (1978) and there was no rainfall from November to March at Satkhira. Similarly, 1302 mm was the maximum rainfall in August (2005) and there was no rainfall from November to March at Hatiya. On the other hand, 1512 mm was the maximum rainfall in July (1983) and no rainfall from November to April at Maizdicourt.

Long-term pattern of rainfall is shown in Fig. 5. Five years average of total monthly rainfall for the three stations are shown in Fig. 6.

Prediction of rainfall for the three stations for 2020, 2025 and 2030 is shown in Table 4. The results showed that 322 mm would be the maximum rainfall in September and there would be no rainfall in December for the year 2020 at Satkhira. Again, 336 mm would be the maximum rainfall in September and there would be no rainfall in December for the year 2025 at Satkhira. Further, 350 mm would be the maximum rainfall in September and there would be no rainfall in December for the year 2030 at Satkhira.

Similarly, 804 mm would be the maximum rainfall in June and there would be no rainfall in January for the year 2020 at Hatiya. Again, 843 mm would be the maximum rainfall in June and there would be no rainfall in January for the year 2025 at Hatiya. Further, 883 mm would be the maximum rainfall in June and there would be no rainfall in January for the year 2030 at Hatiya.

Similarly, 613 mm would be the maximum rainfall in June and there would be no rainfall in December for the year 2020 at Maizdicourt. Again, 622 mm would be the maximum rainfall in June and there would be no rainfall in December for the year 2025 at Maizdicourt. Further, 631 mm would be the maximum rainfall in June and there would be no rainfall in December for the year 2030 at Maizdicourt.

Relative Humidity

40-years average values of monthly average values of relative humidity for the three stations were shown in Table 1. The results showed that 89.04% was the maximum relative humidity in September (1997) and 49.76% was the minimum relative humidity in March (1974) at Satkhira; 93.31% was the maximum relative humidity in July (1994) and 60.86 % was the minimum relative humidity in February (1979) at Hatiya; 91.52% was the maximum relative humidity in July (1987) and 58.72% was the minimum relative humidity in March (1982) at Maizdicourt.

Table 1. Mean monthly maximum and minimum temperatures, calculated from 40-years data for the three selected stations

Months	Stations	Maximum temperature (^{0}C)	Minimum temperature (^{0}C)	Maximum rainfall (mm)	Minimum rainfall (mm)	Maximum relative humidity (%)	Minimum relative humidity (%)
January	Satkhira	27.55	10.40	92	0	81.97	62.24
	Hatiya	26.96	11.85	77	0	82.21	64.59
	Maizdicourt	27.66	11.66	108	0	83.86	64.00
February	Satkhira	31.75	13.16	191	0	78.62	53.73
	Hatiya	30.12	14.50	139	0	79.83	60.86
	Maizdicourt	31.14	13.65	126	0	82.10	63.79
March	Satkhira	36.10	18.68	164	0	77.34	49.76
	Hatiya	32.71	19.21	256	0	84.97	62.79
	Maizdicourt	33.33	15.99	380	0	80.28	58.72
April	Satkhira	37.32	21.07	256	2	79.25	61.07
	Hatiya	33.40	23.03	446	0	83.55	72.12
	Maizdicourt	34.87	19.52	430	0	85.10	68.53
May	Satkhira	38.35	24.21	285	28	79.48	57.59
	Hatiya	33.76	23.15	741	27	88.97	74.41
	Maizdicourt	34.66	21.27	639	67	87.66	71.41
June	Satkhira	35.64	25.12	686	58	86.71	75.14
	Hatiya	32.48	24.46	1464	90	91.00	81.81
	Maizdicourt	33.77	18.61	998	184	89.45	76.33
July	Satkhira	33.60	24.58	685	163	88.10	79.93
	Hatiya	30.87	23.53	1224	90	93.31	85.32
	Maizdicourt	32.34	16.49	1512	384	91.52	83.34
August	Satkhira	33.82	24.56	643	145	87.38	80.24
	Hatiya	31.61	24.28	1302	90	91.79	85.07
	Maizdicourt	32.81	17.69	1307	221	90.76	82.76
September	Satkhira	33.34	24.16	696	98	89.04	79.82
	Hatiya	31.71	23.97	1007	89	91.53	82.38
	Maizdicourt	32.64	20.74	1008	103	90.28	79.55
October	Satkhira	33.92	21.77	469	8	87.55	68.10
	Hatiya	32.18	23.02	525	23	88.97	76.21
	Maizdicourt	32.74	22.95	601	4	87.76	75.48
November	Satkhira	32.16	15.52	181	0	83.21	60.79
	Hatiya	30.96	17.74	251	0	89.12	71.97
	Maizdicourt	30.88	17.25	238	0	89.03	68.53
December	Satkhira	28.82	10.96	134	0	83.97	59.13
	Hatiya	27.34	13.67	93	0	85.24	67.14
	Maizdicourt	27.45	12.14	93	0	86.79	66.31

Long term pattern of relative humidity is shown in Fig. 7. Five years average of monthly relative humidity of the three stations are shown in Fig. 8.

Prediction of relative humidity for 2020, 2025 and 2030 were shown in Fig. 12. at three stations. It was predicted that, for Satkhira station, 87.05% would be the maximum relative humidity in September and 76.57% would be the minimum relative humidity in April for the year 2020. Again, 87.33% would be the maximum relative humidity in September and 76.91% would be the minimum relative humidity in April for the year 2025. Further, 87.61% would be the maximum relative humidity in September and 77.19% would be the minimum relative humidity in May for the year 2030.

Similarly, 89.32% would be the maximum relative humidity in July and 76.41% would be the minimum relative humidity in February for the year 2020 for Hatiya. Again, 89.39% would be the maximum relative humidity in July and 77.28% would be the minimum relative humidity in February for the year 2025. Further, 89.45% would be the maximum relative humidity in July and 78.14% would the minimum relative humidity in February for the year 2030.

Similarly, 87.40% would be the maximum relative humidity in July and 76.50% would be the minimum relative humidity in February for the year 2020 for Maizdicourt. Again, 87.32% would be the maximum relative humidity in July and 76.76% would be the minimum relative humidity in February for the year 2025. Further, 87.25% would be the maximum relative humidity in July and 77.03% would be the minimum relative humidity in February for the year 2030.

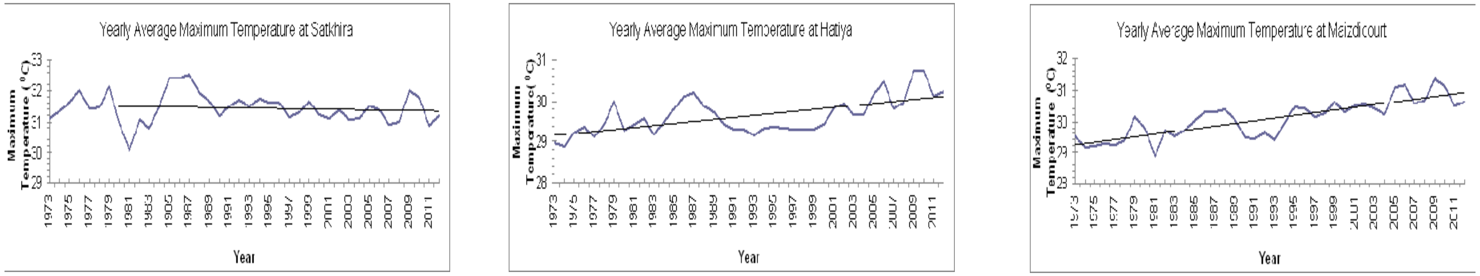

Fig. 1. Long-term pattern of maximum temperature for the three stations

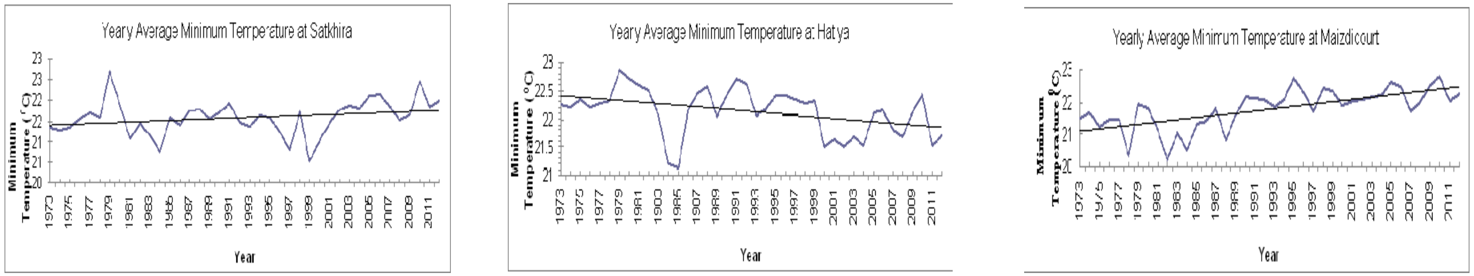

Fig. 2. Long-term pattern of minimum temperature for the three stations

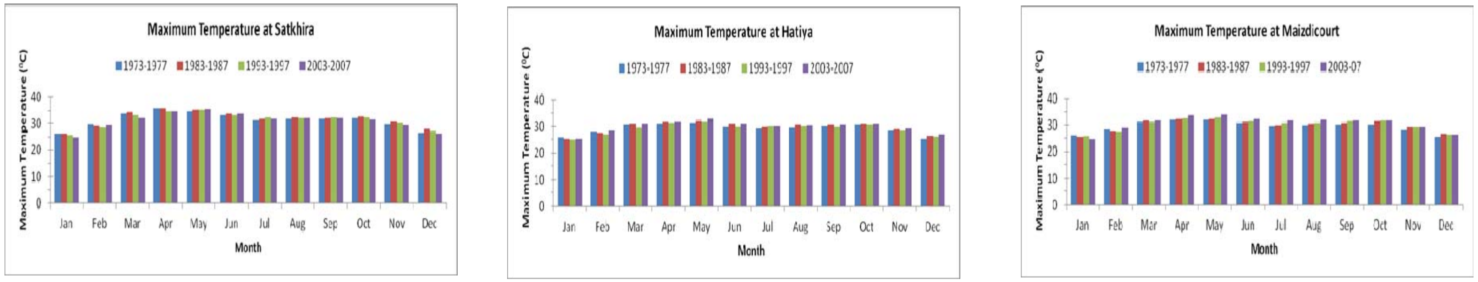

Fig. 3. Five years average of monthly maximum temperature for the three stations

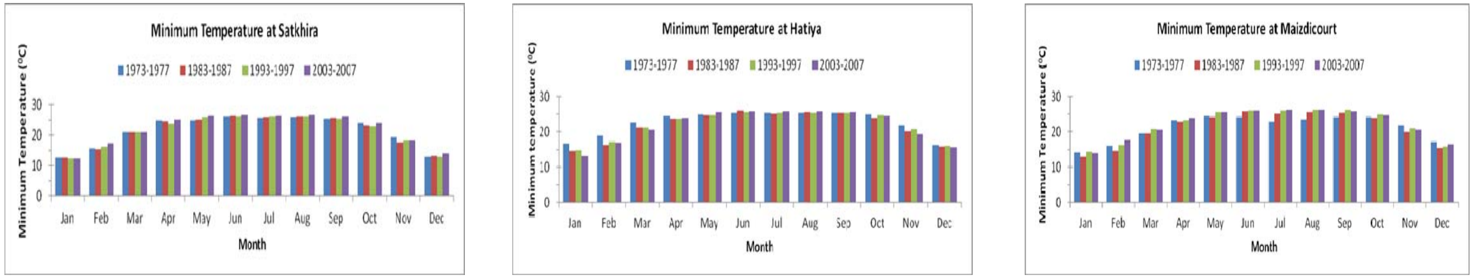

Fig. 4. Five years average of monthly minimum temperature for the three stations

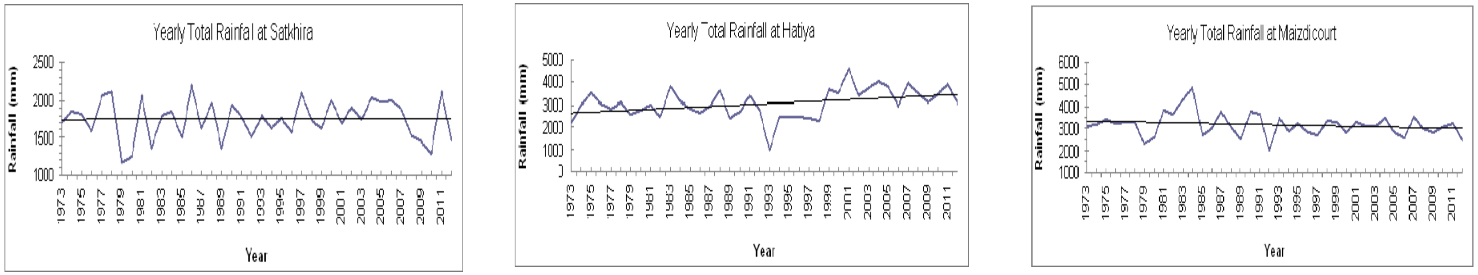

Fig. 5. Long-term pattern of rainfall for the three stations

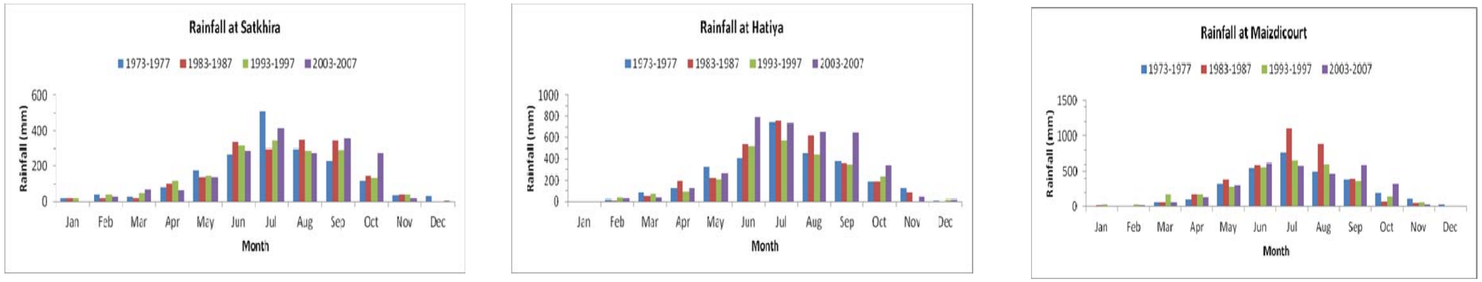

Fig. 6. Five years total of monthly rainfall for the three stations

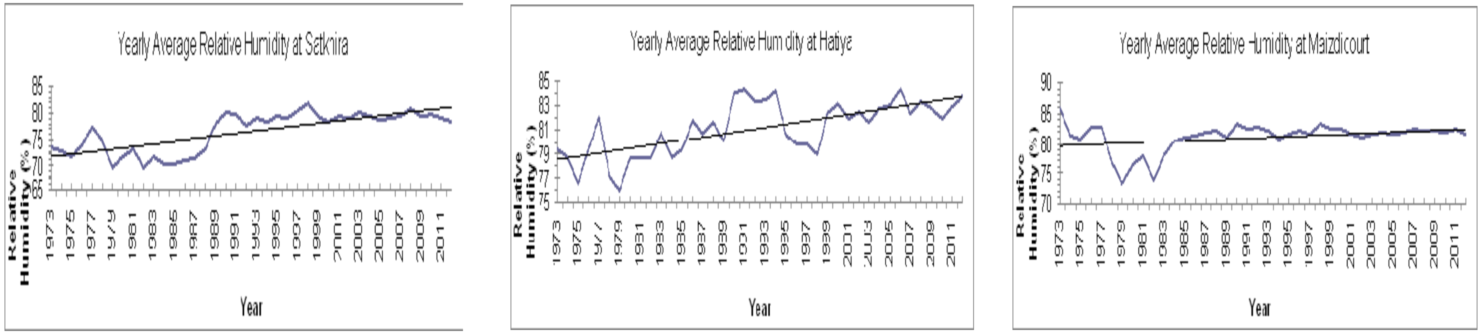

Fig. 7. Long-term pattern of relative humidity for the three stations

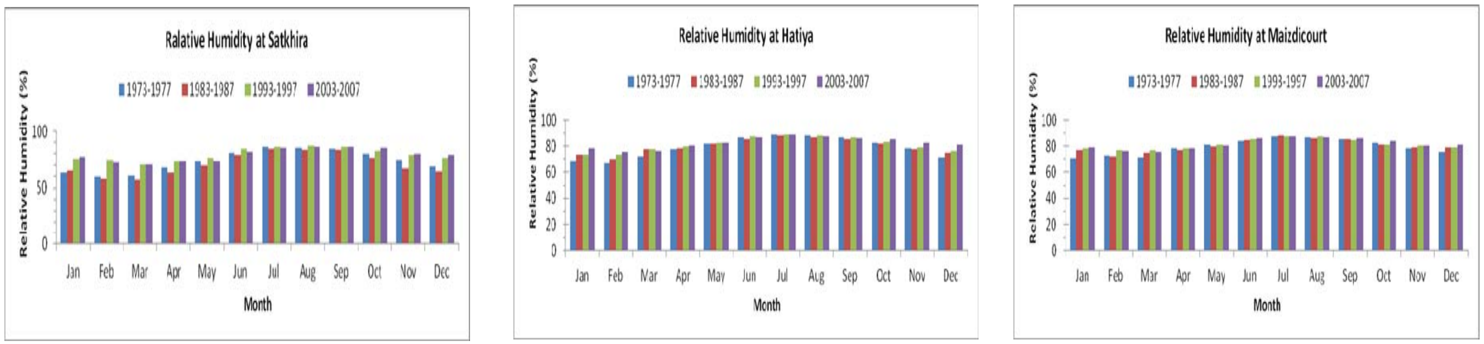

Fig. 8. Five years average of monthly relative humidity for the three stations

Table 2. Prediction of maximum temperature (^{0}C)

Months	Satkhira			Hatiya			Maizdicourt		
	2020	2025	2030	2020	2025	2030	2020	2025	2030
January	24.44	24.21	23.99	25.65	25.74	25.84	24.73	24.60	24.48
February	28.64	28.58	28.53	29.13	29.36	29.58	28.71	28.76	28.82
March	32.40	32.23	32.06	31.25	31.32	31.39	32.57	32.76	32.96
April	34.44	34.28	34.11	32.42	32.47	32.52	34.91	35.29	35.67
May	35.56	35.62	35.67	32.73	32.84	32.95	34.77	35.16	35.55
June	33.90	34.00	34.09	31.27	31.39	31.52	32.89	33.17	33.45
July	32.78	32.89	33.01	30.46	30.55	30.64	32.42	32.76	33.09
August	32.57	32.64	32.72	30.98	31.10	31.22	32.79	33.13	33.47
September	32.57	32.62	32.67	31.24	31.33	31.42	32.76	33.04	33.32
October	32.09	32.05	32.02	31.45	31.55	31.65	32.59	32.81	33.03
November	29.53	29.40	29.27	29.78	29.91	30.05	30.02	30.16	30.30
December	26.12	25.99	25.86	27.24	27.43	27.62	26.34	26.41	26.49

Table 3. Prediction of minimum temperature (^{0}C)

Months	Satkhira			Hatiya			Maizdicourt		
	2020	2025	2030	2020	2025	2030	2020	2025	2030
January	12.15	12.12	12.10	13.18	12.93	12.69	14.47	14.55	14.63
February	16.11	16.16	16.21	16.37	16.22	16.08	17.19	17.33	17.46
March	21.32	21.37	21.43	20.74	20.61	20.47	21.98	22.23	22.48
April	24.32	24.31	24.30	23.67	23.63	23.59	24.32	24.45	24.58
May	26.27	26.40	26.53	25.27	25.32	25.37	25.61	25.79	25.97
June	26.95	27.04	27.14	25.92	25.97	26.02	26.45	26.61	26.77
July	26.80	26.91	27.01	25.78	25.82	25.87	26.76	26.96	27.16
August	26.66	26.73	26.80	25.92	25.99	26.05	26.65	26.83	27.01
September	26.07	26.13	26.18	25.80	25.85	25.90	26.52	26.70	26.88
October	23.38	23.36	23.35	24.29	24.22	24.15	25.12	25.23	25.34
November	18.65	18.70	18.75	19.42	19.18	18.93	20.99	21.07	21.14
December	13.48	13.53	13.59	15.00	14.80	14.59	16.90	17.10	17.30

Table 4. Prediction of rainfall (mm)

Months	Satkhira			Hatiya			Maizdicourt		
	2020	2025	2030	2020	2025	2030	2020	2025	2030
January	6	6	6	0	0	0	1	1	1
February	25	24	24	10	9	9	13	13	13
March	23	23	23	28	27	27	43	41	40
April	52	49	47	89	85	81	104	101	98
May	191	195	199	299	302	305	302	294	285
June	280	285	290	804	843	883	613	622	631
July	299	295	290	754	764	774	498	460	423
August	281	278	275	516	514	512	460	451	442
September	322	336	350	482	498	514	336	334	332
October	114	117	120	358	386	413	282	299	317
November	5	5	5	3	3	3	10	6	2
December	0	0	0	2	2	2	0	0	0

Table 5. Prediction of relative humidity (%)

Months	Satkhira			Hatiya			Maizdicourt		
	2020	2025	2030	2020	2025	2030	2020	2025	2030
January	84.13	86.34	88.54	82.42	83.93	85.44	82.80	83.80	84.80
February	79.56	81.57	83.57	76.41	77.28	78.14	76.50	76.76	77.03
March	76.87	78.82	80.77	79.58	80.22	80.86	77.88	78.07	78.25
April	76.57	77.76	78.95	81.24	81.61	81.99	79.49	79.58	79.68
May	76.62	76.91	77.19	84.50	84.86	85.23	80.43	80.26	80.09
June	83.62	83.95	84.28	88.00	88.19	88.37	86.83	86.91	86.99
July	84.76	84.70	84.65	89.32	89.39	89.45	87.40	87.32	87.25
August	86.31	86.48	86.66	88.07	88.06	88.04	86.50	86.50	86.50
September	87.05	87.33	87.61	87.00	87.12	87.23	86.07	86.16	86.24
October	86.07	86.96	87.85	87.82	88.50	89.18	84.02	84.29	84.55
November	83.41	84.76	86.11	84.86	85.93	87.01	81.13	81.44	81.76
December	85.28	87.42	89.56	86.57	88.19	89.80	83.90	84.82	85.74

Conclusion

The study revealed that there were evidences of gradual changes of climatic parameters over the years. Such changes were not consistent in all regions and not evenly distributed over the seasons. The trend lines of maximum temperature gradually increased at Hatiya and Maizdicourt whereas slightly decreased at Satkhira. The minimum temperature slightly increased at Satkhira, but gradually decreased at Hatiya, whereas gradually increased at Maizdicourt. The trend lines of total rainfall were more or less same in Satkhira, but slightly increased in Hatiya, whereas slightly decreased at Maizdicourt. The trend lines of relative humidity increased at the three different stations, but highly increased at Satkhira and Hatiya, whereas slightly increased at Maizdicourt. It was predicted that the trend lines of maximum temperature would be gradually increased day by day in the summer season. The minimum temperature would be gradually decreased day by day in the winter season for the three selected stations. The trend lines of total rainfall would be increased in rainy season and decreased in summer season. The trend lines of relative humidity would be increased in rainy season and decreased in summer season.

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