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CHEMICAL PROPERTIES, MACRO AND MICRONUTRIENT STATUS OF THE OLD HIMALAYAN PIEDMONT PLAIN SOILS OF BANGLADESH

M. F. Islam[1], M. Jahiruddin[2], A. Parvin[3]

Abstracts

There are thirty Agroecological zones (AEZs) of Bangladesh. Old Himalayan Piedmont Plain (AEZ 1) is one of them. The Soil Resource and Development Institute (SRDI) has generated bench line information of different micronutrients status across the AEZs of Bangladesh. Data on micronutrient as well as macronutrient status of soils across the AEZs need to be updated on regular basis. With advancement of time, new micronutrient deficiency may arise and deficiency level may increase. The overall fertility status is not satisfactory in Bangladesh. Sixteen elements are known to be essential for normal growth and development of plants. Macronutrients (N, P, K, S, Ca, Mg) are required relatively in large quantities. Seven elements (Zn, Fe, Mn, Cu, B, M_O and Cl) essential for plant growth but in a small amount are commonly referred to as micronutrient. Fifty soil samples were collected from 50 sites at 0-15 cm depth of intensively cropped area covering nine soil series. The sampling sites were selected based on the existing cropping pattern, land type and soil series. The objective was to evaluate some chemical properties and available micronutrient (except Cl and Mo) status and their relationship among nutrient variables in soils. Depending on the micronutrient status/levels, the soils have been categorized into very low, low, medium, optimum, high and very high. In the AEZ 1, the 70% and 42% of analyzed soil samples were found to be deficient in Zn and B while the remaining micronutrients (Cu, Mn and Fe) shown to be sufficient. The soil Cu status of 84%, the Mn of 68% and Fe status of 100% were found as 'very high' in the AEZ. The availability of B indicating positive and significantly correlated with the soil pH, available S, exchangeable K and Ca. Zinc showed significant correlation with P and exchangeable K of soils. Iron showed significant correlation with soil total N. Copper showed significant correlation with pH, organic matter, available S, exchangeable Mg of soils.

Key words: Old Himalayan Piedmont Plain, chemical properties, macro and micronutrients, correlation.

Introduction

The old Himalayan Piedmont Plain (AEZ 1) is located to the north of Barind Tract in the most of Thakurgaon, Panchagarh and north western parts of Dinajpur district and comprises of the feet of some coalesced alluvial fan formed by the rivers, washing the adjacent Himalayan slope. It has complex relief pattern comprising broad and narrow floodplain ridge and linear depression. Under AEZ 1, there are 23 number of soil series.

[1]Bangladesh Institute of Nuclear Agriculture, BAU Campus, Mymensingh-2202, Bangladesh
[2]Department of Soil Science, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh
[3]Ex. Deputy Manager (Agriculture), Bangladesh Institute of ICT in Development.

Seven general soil types occur in the region of which Non-calcareous Brown floodplain soils, Black Terai soils and Non-calcareous dark grey floodplain soils predominate. Top soils are very strongly to slightly acidic, organic matter contents are relatively higher than the other floodplain areas (FRG, 2012). The texture of the soils varied from clay loam to sandy loam. The irregular vertical distribution patterns of sand/silt ratio in the profiles indicate the heterogeneous nature of the parent materials. The pH of the soils ranged from 5.4 to 6.26. The organic matter content is generally low. The C/N ratios of the soils varied from 4.3 to 10.3. The cation exchange capacity (CEC) in most of the soils is low. Calcium and magnesium are the dominant cations in all the soils (Uddin *et al*., 2012). The major land type comprises of 58% highland and 34% medium highland of AEZ 1 area (3,98,154 ha). Mica and Chlorite is predominant clay minerals of the soils (FRG, 2012).

Soil plays a key role in determining the productivity of an agro-ecosystem. The productivity of a soil mainly depends upon its ability to supply essential nutrients to plants. The deficiency of micronutrients has become major constraint to productivity, stability and sustainability of soils (Bell and Dell, 2008). Micronutrient contents of soil and their availability to plant are assessed by the mineral present and weathering processes.

Seven elements (Zn, Fe, Mn, Cu, B, Mo and Cl) are essential for plant growth but in a small amount are commonly referred to as micronutrients. Lack of any one of them in the soil can limit plant growth, even when all the other essential nutrients are present in adequate amounts (PPI, 1983). Among the seven micronutrients, data on the status of Cu, Fe, Mn, Zn, and B of Bangladesh soils are available while the Cl and Mo status is yet to be studied. Of the five elements, Fe has never been reported to be deficient, whereas Zn and B are the most widely deficient and Cu and Mn are deficient in some areas (Islam *et al.,* 1992). Zinc deficiency was observed by Bangladesh Rice Research Institute and Department of Agricultural Extension (Mukhopadhayay *et al.,* 1986). In general, Ganges floodplain and coastal saline soils and the area covered by HYV rice are deficient in Zn. The reasons behind Zn deficiency in the soils of Bangladesh may be high soil pH, presence of lime materials, soil submergence, and interaction with phosphate ion. Deficiencies of other micronutrients were caused mainly by intensive cultivation with HYV crops. Micronutrients have received less attention in fertilizer management research, development and extension in this country.

In Bangladesh, Paddy soils under submergence condition countenance by unavailability of S and Zn in rice crop. Other dry land crops also face the problem of S and Zn deficiencies in many areas. Boron was reported to be deficient in some regions. Magnesium deficiency was found in the coarse-textured soils of Old Himalayan Piedmont Plain, Brown hill soils and Grey floodplain soils of the northern part of the country. The Ca reserve of many floodplain soils is depleting due to decalcification process and deficiency of Ca is probable in near future. Deficiencies of Cu and Mn were reported but very rare. The overall fertility status is not satisfactory (Moslehuddin *et al*., 1997).

Sidhu and Sharma (2010) reported that the available micronutrients (Zn, Cu, Mn and Fe) increased with increase in organic carbon and decreased with increase in sand content, pH, and calcium carbonate. Uptake of micronutrient is affected by the presence of major nutrients due to either negative or positive interactions (Fageria, 2001). High phosphate content of soils or high fertilization with phosphate may reduce the uptake of zinc and other nutrients (Kizilgoz and Sakin, 2010). Thus, indiscriminate use of macronutrients may affect uptake of micronutrients.

Islam *et al.* (1992) reported that the application of Zn increased the yield of rice, maize, and chickpea. Mondal *et al.* (1991) found, application of Zn and B increased the yield of rice (Var. BR11) in the Old Brahmaputra floodplain soil, but application of Cu and Mo had no such positive effect. In wheat, Jahiruddin *et al.* (1995) recorded increased yield due to B application but Jahiruddin *et al.* (1992) got no response of wheat to applied Cu and Mo. The objective of this study was to evaluate some chemical properties, macronutrients and available micronutrients (Fe, Cu, Zn, Mn and B) status and their relationship among nutrient variables in soils.

Materials and Methods

A total of 50 soil samples were collected from 50 sites at a depth of 0-15 cm (top soil) of intensively cropped area covering nine soil series including Atowari, Amgaon, Baliadangi, Birganj, Jamun, Pirgacha, Ranishankail, Sreerampur and Gongachra of AEZ 1 for laboratory analysis. The sampling sites were selected based on the land type, existing cropping pattern and soil series. Ground positioning system (GPS) reading was recorded on every site of soil sample collection. Some basic information like village, union, upazila, land type, soil series and land use were noted. After collection, the soil samples were put in the polythene bags and every bag was tagged with the basic information of the soil (Table 1).

Every soil sample was spread on a brown paper in the laboratory for air-drying and some unwanted materials viz. stones, pebbles, gravels and plant roots were removed prior to air-drying. The air-dry soil was ground by mortar and pestle and screened through a 2 mm (10-mesh) sieve. The samples were kept into plastic bottles for chemical analysis.

The soil samples were processed and analyzed in the laboratory for some basic properties (pH and organic matter), macronutrients (N, P, K, S, Ca and Mg concentrations) and micronutrients (Zn, B, Cu, Fe and Mn concentrations). Available Zn, Cu, Mn and Fe were extracted by 0.05M DTPA solution (pH 7.3) maintaining 1:2 soil-extractant ratio. The extracted level was measured by flame AAS (Lindsay and Norvell, 1978). Soil B was extracted by hot water-0.02 M $CaCl_2$ solution (1:2). The extractable B was determined by spectrophotometer following azomethine-H method (Keren, 1996). The pH of soils was determined at a soil-water ratio (1:2.5) using a pH meter and the total nitrogen by Kjeldahl's method (Jackson, 1967). Exchangeable Ca^{++} and Mg^{++} were determined by atomic absorption Spectrophotometer, while K^+ was analyzed by flame photometer.

Table 1. Some basic information of soil samples collected from Old Himalayan Piedmont Plain (AEZ 1) (n=50)

Sample no.	Location (Village, Union & Upazila)	GPS Reading	Land type	Land Use (R-Kh1-Kh2)
	Series: Jamun			
1.	Nashipur, Chehelgazi, Dinajpur Sadar	N 25^0 43' 07.9" E 88^0 39' 27.7"	MHL	Potato-Boro rice-T. Aman rice
	Series: Amgaon			
2.	Nashipur, Chehelgazi, Dinajpur Sadar	N 25^0 43' 12.8" E 88^0 39' 19.6"	HL	Maize/Boro rice -Fallow-T. Aman rice
	Series: Gongachara			
3.	Amoir, Sunderban, Dinajpur Sadar	N 25^0 48' 28.2" E 88^0 41' 36.2"	MHL	Boro rice -Fallow-T. Aman rice
	Series: Pirgacha			
4.	Chujkuria, Vhognagar, Birgong	N 25^0 54' 39.4" E 88^0 34' 3.7"	HL	Sugarcane/Vegetable-T. Aman rice
	Series: Atowari			
5.	Dulotpur, Jagannathpur, Thakurgau	N 25^0 58' 29.6" E 88^0 30' 47.2"	HL	Banana, Boro rice -Fallow - T. Aman rice
	Series: Ranishankail			
6.	Kornai, Bahelgazi, Dinajpur	N 25^0 42' 32.3" E 88^0 38' 53.4"	HL	Boro rice -T. Aman rice-Potato
7.	Nashipur, Chehelgazi, Dinajpur Sadar	N 25^0 43' 14.3" E 88^0 40' 29.2"	HL	Vegetables-Vegetables - Vegetables
8.	East Saidpur, Sunderpur, Kaharol	N 25^0 45' 11.5" E 88^0 40' 50.5"	HL	Sugarcane
9.	East Saidpur, Sunderpur Kaharol	N 25^0 46' 4.0" E 88^0 40' 28.3"	HL	Sugarcane/Banana
10.	Rampur, Mukundapur Kaharol	N 25^0 49' 18.2" E 88^0 39' 54.6"	HL	Potato/Radish, Maize
11.	Chaky, Shujalpur Birgong	N 25^0 52' 51.4" E 88^0 38' 4.5"	HL	Vegetables/Potato/mustard – T. Aman rice
12.	Kornai, Bahelgazi Dinazpur	N 25^0 42' 27.8" E 88^0 39' 16.9"	HL	Potato -T. Aman - Vegetables
	Series: Sreerampur			
13.	Nashipur, Chehelgazi, Dinajpur Sadar	N 25^0 43' 7.4" E 88^0 40' 38.7"	MHL	Boro rice - Fallow-T. Aman rice
14.	Noshipur, Bahelgazi, Dinazpur	N 25^0 42' 54.6" E 88^0 39' 47.7"	MHL	Boro rice - Fallow-T. Aman rice
	Series: Jamun			
15.	Uttar Mohespur, Fazilpur, Dinajpur Sadar	N 25^0 42' 47.6" E 88^0 40' 58.7"	HL	Wheat - Jute - Vegetable
16.	Boiltor, Fazilpur, Dinajpur Sadar	N 25^0 43' 23.7" E 88^0 41' 39.3"	HL	Boro rice-Fallow-T. Aman rice
17.	Kalikapur, Sunderban, Dinajpur Sadar	N 25^0 41' 38.3" E 88^0 42' 1.3"	HL	Wheat/Maize-Boro rice -T. Aman rice

Table 1. Continued

Sample no.	Location (Village, Union & Upazila)	GPS Reading	Land type	Land Use (R-Kh1-Kh2)
18.	Khandagau, Jagannathpur, Thakurgau	N 25^0 57' 13.6" E 88^0 32' 2.0"	HL	Boro rice -Fallow-T. Aman rice
19.	Khandagau, Jagannathpur, Thakurgau	N 25^0 57' 43.2" E 88^0 31' 38.0"	HL	Potato -T. Aman
20.	Khandagau, Jagannathpur, Thakurgau	N 25^0 57' 38.4" E 88^0 31' 37.8"	HL	Sugarcane, Boro rice -Fallow-T. Aman rice
21.	Tutapara, Jagannathpur, Thakurgau	N 25^0 59' 27.3" E 88^0 29' 51.8"	HL	Potato -T. Aman rice
22.	Narun, Thakurgau Sadar	N 25^0 59' 36.5" E 88^0 29' 55.5"	HL	Brinjal-T. Aman rice
23.	Boiltor, Fazilpur, Dinajpur Sadar	N 25^0 43' 23.7" E 88^0 41' 39.3"	HL	Boro rice -Fallow-T. Aman rice
	Series: Pirgacha			
24.	Kalikapur, Sunderban, Dinajpur Sadar	N 25^0 41' 14.0" E 88^0 41' 51.4"	HL	Banana/Onion/Garlic/Potato -Vegetable
25.	East Sadipur, Sunderpur, Kaharol	N 25^0 45' 20.6" E 88^0 40' 55.5"	HL	Maize/Potato
26.	East Mallikpur, Sundarbon, Kaharol	N 25^0 47' 54.1" E 88^0 40' 40.5"	HL	Potato/vegetables-vegetables
27.	Vhognagar, Birgong	N 25^0 54' 42.6" E 88^0 34' 8.0"	HL	Potato- Vegetable
	Series: Birganj			
28.	Garnurpur, Sunderpur, Kaharol	N 25^0 46' 5.3" E 88^0 40' 21.6"	HL	Maize/Mustard/Wheat/Potato-Fallow-T. Aman rice
29.	Garnurpur, Sunderpur, Kaharol	N 25^0 46' 21.5" E 88^0 40' 19.7"	HL	Sugarcane; Boro rice -Fallow-T. Aman rice
30.	East Mallikpur, Sundarbon, Kaharol	N 25^0 47' 28.8" E 88^0 40' 42.2"	HL	Sugarcane; Potato-Fallow-T. Aman rice
31.	Jogdal, Sujalpur, Birgong	N 25^0 50' 48.9" E 88^0 39' 22.2"	HL	Potato/mustard-T. Aman rice
32.	Kurpur, Pouroshava, Birgong	N 25^0 52' 18.9" E 88^0 38' 26.6"	HL	Banana, Potato/mustard-T. Aman rice
33.	Shitly, Shujalpur, Birgong	N 25^0 53' 34.4" E 88^0 37' 5.9"	HL	Potato/Boro -T. Aman rice
34.	Prannagar, Shator, Birgong	N 25^0 55' 21.1" E 88^0 33' 16.5"	HL	Caulifower-Brinjal
	Series: Baliadangi			
35.	Bhatgaon, Sundarbon, Kaharol	N 25^0 48' 35.5" E 88^0 40' 35.6"	MHL	Potato/mustard-Fallow- T. Aman rice
36.	Rampur, Mukundapur, Kaharol	N 25^0 48' 57.7" E 88^0 40' 17.4"	MHL	Wheat/mustard-Fallow- T. Aman rice
37.	Rampur, Mukundapur, Kaharol	N 25^0 49' 17.7" E 88^0 39' 44.5"	MHL	Boro rice-Fallow-T. Aman rice

Table 1. Continued

Sample no.	Location (Village, Union & Upazila)	GPS Reading	Land type	Land Use (R-Kh1-Kh2)
38.	Rampur, Mukundapur, Kaharol	N 25^0 49' 49.1" E 88^0 39' 45.3"	MHL	Boro rice -Fallow-T. Aman rice
39.	Rampur, Mukundapur, Kaharol	N 25^0 49' 52.0" E 88^0 39' 38.4"	MHL	Boro rice -Fallow-T. Aman rice
40.	Chaky, Shujalpur, Birgong	N 25^0 53' 3.4" E 88^0 37' 41.6"	MHL	Boro rice -Fallow-T. Aman rice
41.	Dhamikhatra, Nijpara, Birgong	N 25^0 53' 15.0" E 88^0 37' 27.2"	MHL	Boro rice -Fallow-T. Aman rice
42.	Dhamikhatra, Nijpara, Birgong	N 25^0 53' 21.1" E 88^0 37' 22.9"	MHL	Boro rice -Fallow-T. Aman rice
43.	Vabki, Vhognagar, Birgong	N 25^0 53' 49.1" E 88^0 36' 44.4"	MHL	Boro rice -Fallow-T. Aman rice
44.	Kurpur, Pouroshava, Birgong	N 25^0 51' 54.3" E 88^0 38' 46.4"	HL	Boro rice -Fallow-T. Aman rice
45.	Kurpur, Pouroshava, Birgong	N 25^0 52' 8.6" E 88^0 38' 46.7"	HL	Boro rice -Fallow-T. Aman rice
46.	Kurpur, Pouroshava, Birgong	N 25^0 52' 4.4" E 88^0 38' 40.4"	HL	Boro rice -Fallow-T. Aman rice
47.	Shitly, Shujalpur, Birgong	N 25^0 53' 34.0" E 88^0 37' 2.4"	HL	Boro rice -Fallow-T. Aman rice
48.	Vhognagar, Birgong	N 25^0 54' 30.6" E 88^0 35' 2.2"	HL	Boro rice -Fallow-T. Aman rice
49.	Uttar Raghunathpur, Shator, Birgong	N 25^0 56' 43.0" E 88^0 32'33.6"	HL	Potato/Boro rice -Fallow -T. Aman rice
50.	Rahimanpur, Thakurgau Sadar	N 26^0 03' 35.5" E 88^0 23' 53.7"	HL	Potato -T. Aman rice

MHL=Medium high land; HL= High land

Statistical analysis

The standard deviation of a set x_1, x_2, x_3 ……x_n was measured by

$$Sd(x) = \sum \sqrt{\frac{(xi - X)^2}{n}}$$

Where, sd (x) = Standard deviation of x variable

x_i = x variables

$\bar{x}$ = Mean of x variable

n = number of observations

And the relationship between different soil characteristics and micronutrients were determined using correlation coefficients

$$r = \sqrt{\frac{SS(xy)}{SS(x)}}$$

Where: r = Correlation coefficient
SP (xy) = Sum product of x, y variables
SS (x) = Sum of square of x variable
SS (y) = Sum of square of y variable

Results and Discussion

pH: The pH value of the AEZ 1 soils was found acidic in nature and value ranged from 4.05-6.00 with a mean of 4.91±0.34 (Table 2). Based on soil test data, all the soil samples were found pH value below 6. The data further reveals that most of the soil samples were acidic in nature. This finding has relevance with the findings of Uddin *et al.* (2012), who reported that pH value of four soil series namely Baliadangi, Ranisankail, Domar, Dimla from Old Himalayan Piedmont soils ranged from 5.4-6.26 with a mean 5.9.

Organic matter: The percentage of organic matter (OM) ranged from 0.38-4.13% with a mean value 1.90±0.80% (Table 2). From the soil samples, 86% were found in medium organic matter (1.8-3.4%). It may be concluded that studied soils contain medium amount of organic matter because surface soil (0-15 cm) content more organic matter and gradually decrease with the increase of soil depth. The organic matter of more than half of cultivated soils in Bangladesh is said to be below the critical level of 1.5% and still declining at an alarming rate (Hossain, 2012).

Macronutrients status: Total N content of soils (n=50) varied from 0.019-0.206%, available P from 8.18-56.65 mg kg^{-1} and available S from 9.00-28.20 mg kg^{-1}, with the corresponding mean values of 0.09±0.04%, 43.97±32.39 mg kg^{-1} and 66.53±16.82 mg kg^{-1}, respectively (Table 2). The amount of exchangeable K and Ca^{++} of soils ranged from 0.02-0.42 cmol kg^{-1} and 1.05-7.96 cmol kg^{-1} with a mean of 0.150±0.11 and 2.87±1.18 cmol kg^{-1}, accordingly. The highest exchangeable Ca^{++} was found in the soils of Pirgacha series while the lowest value was found in Juman series (Table 2). This finding was in agreement with Uddin *et al*. (2012) who stated that exchangeable Ca^{++} is by far the most dominant ion in all the soils.The exchangeable Mg^{++} in all the soil series ranged from 0.19-2.43 cmol kg^{-1} with a mean of 0.58±0.40 cmol kg^{-1}. The highest Mg^{++} value of 2.43 cmol kg^{-1} was observed from Jamun soils. Considering exchangeable Ca^{++} and Mg^{++} status, 62% and 80% of soil samples were found below critical level, respectively. About 49%, 22%, 65%, 31% 62% and 80% soil samples were found 'low' interpretation class in N, P, K, S, Ca and Mg status (Table 3). This result is based on the interpretation of soil test values in relation to critical limit of the nutrient (FRG, 2012). Portch and Islam (1984) found that 14% and 21% of the soils were below the critical level for Ca.

Table 2. Chemical properties and nutrient status of soils from Old Himalayan Piedmont Plain (AEZ 1) (n=50)

Sample No.	pH	OM (%)	Ca	Mg	K	Total N (%)	P	S	B	Zn	Fe	Cu	Mn
			(cmol kg^{-1})				mg kg^{-1}						
1.	4.71	1.86	2.85	0.32	0.04	0.093	9.3	64.4	0.32	0.29	89.45	0.73	0.88
2.	4.98	1.34	3.56	0.35	0.04	0.067	30.96	88.5	0.33	0.23	128.8	0.59	0.42
3.	4.74	0.48	3.37	0.43	0.06	0.024	13.36	112.7	0.58	0.17	56.92	0.79	0.21
4.	6.00	1.41	7.96	1.36	0.55	0.071	105.3	100.1	0.85	2.34	103.3	1.48	39.87
5.	5.13	2.44	2.61	0.33	0.11	0.122	51.8	59.7	0.23	0.52	81.18	1.31	1.33
6.	5.04	1.65	3.35	1.16	0.15	0.083	9.5	66.4	0.12	0.36	132.3	2.17	3.72
7.	4.71	1.31	3.73	0.52	0.09	0.066	112.1	81.1	0.53	0.8	63.74	0.35	36.47
8.	5.23	1.38	2.72	0.2	0.17	0.069	77.08	37.3	0.39	0.67	165.5	1.18	11.23
9.	4.79	2.41	3.61	0.49	0.42	0.121	56.65	54.5	0.7	0.3	159.1	1.3	14.34
10.	4.93	1.89	3.25	0.45	0.09	0.095	13.3	69.1	0.61	0.6	161.5	1.61	6.04
11.	4.75	1.93	2.03	0.63	0.12	0.097	28.35	46.2	0.1	0.82	129.1	1.16	8.45
12.	4.76	1.82	1.81	0.70	0.13	0.091	14.69	64.6	0.34	0.28	114.3	2.63	5.66
13.	4.74	1.79	3.19	0.43	0.02	0.090	8.28	57.2	0.44	0.29	133.4	1.07	7.8
14.	5.09	1.44	2.97	1.22	0.51	0.072	135.7	82.4	0.05	3.46	102.3	0.86	57.33
15.	4.73	1.27	6.48	1.45	0.07	0.064	60.16	87.6	0.51	0.97	188.6	1.89	81.95
16.	4.75	1.20	2.43	0.20	0.04	0.060	11.44	55.2	0.38	0.23	92.74	1.25	0.65
17.	4.63	1.17	2.76	0.21	0.18	0.059	102.7	40.6	0.07	0.23	55.13	0.22	2.98
18.	4.85	1.58	1.64	0.34	0.25	0.079	24.65	67.2	0.76	0.59	173.4	1.21	6.11
19.	4.93	2.10	2.18	0.39	0.11	0.105	30.4	62.0	0.36	0.6	177.6	1.61	5.08
20.	5.33	3.64	3.17	0.56	0.09	0.182	31.22	59.2	0.22	0.74	69.82	1.66	3.75
21.	4.05	2.27	1.05	0.19	0.13	0.114	77.19	35.8	0.13	0.58	66.05	0.72	0.27
22.	5.07	2.06	1.98	0.45	0.13	0.10	70.30	56.80	0.03	1.24	73.44	0.95	2.51
23.	6.00	4.75	1.20	2.43	0.20	0.04	60.0	11.44	0.52	0.38	0.23	2.74	1.25
24.	4.96	1.48	2.99	0.29	0.10	0.074	9.19	56.2	0.27	0.15	113	1	0.16
25.	4.59	1.31	2.27	0.19	0.12	0.066	43.71	68.3	0.29	0.2	45.07	1.14	11.92
26.	5.25	1.86	3.6	0.62	0.37	0.093	83.52	76.8	0.4	0.44	229	1.28	22.21
27.	4.95	1.20	2.56	0.88	0.13	0.06	54.26	86.6	0.31	0.71	144.10	1.14	71.06
28.	4.59	1.86	2.69	0.2	0.11	0.093	42.06	57.3	0.21	0.16	181.2	1.02	47.12
29.	5.07	1.99	3.45	0.38	0.15	0.100	28.73	87.5	0.45	0.21	97	0.85	53.98
30.	5.26	1.79	3.75	0.7	0.34	0.090	46.1	76.0	0.48	0.6	86.99	0.85	34.81
31.	4.79	0.38	4.70	0.52	0.11	0.019	10.71	61.2	0.4	0.27	101.6	0.99	0.19
32.	4.46	1.12	1.79	0.52	0.15	0.056	52.3	66.05	0.68	2.78	172.6	0.75	21.24
33.	4.74	4.12	3.51	0.91	0.14	0.206	10.71	63.5	0.27	0.34	209.7	2.56	19.01
34.	5.06	1.96	2.89	0.59	0.11	0.098	43.48	73.0	0.21	1.66	229.7	1.25	4.15
35.	5.21	1.99	3.76	0.54	0.25	0.100	24.62	74.5	0.51	0.2	167	2.06	20.6
36.	4.92	1.82	3.02	0.28	0.08	0.091	11.94	63.0	0.29	0.1	107.1	0.91	8.58
37.	4.41	1.24	2.46	0.24	0.15	0.062	64.78	61.3	0.44	0.16	58.87	0.31	22
38.	4.6	2.13	2.63	0.20	0.10	0.107	34.8	60.4	0.27	1.29	183.9	1.17	2.61
39.	5.03	1.51	2.57	0.58	0.13	0.076	49.44	74.1	0.49	2.08	171.5	0.67	11.01
40.	5.05	2.24	2.34	0.55	0.14	0.112	57.86	69.2	0.35	1.4	152.3	1.06	10.72
41.	4.87	1.51	2.01	0.48	0.14	0.076	40.6	92.4	0.38	1.93	171.4	1.18	10
42.	4.77	2.44	2.03	0.66	0.15	0.122	19.81	67.5	0.48	0.93	139.9	1.48	7.88
43.	4.90	2.27	2.19	0.78	0.13	0.114	42.89	66.6	0.3	0.79	181.4	1.37	2.97

Table 2. Continued

Sample No.	pH	OM (%)	Ca	Mg	K	Total N (%)	P	S	B	Zn	Fe	Cu	Mn
			(cmol kg^{-1})				mg kg^{-1}						
44.	4.83	2.54	1.96	0.58	0.14	0.127	22.2	59.4	0.29	0.83	158	1.55	2.26
45.	4.85	2.85	2.05	0.45	0.14	0.143	44.86	59.0	0.23	1.69	192.4	2.19	5.59
46.	4.74	1.31	1.55	0.51	0.15	0.066	45.37	66.12	0.42	3.04	117.9	0.82	43.38
47.	4.49	2.13	1.57	0.31	0.12	0.107	34.78	74.8	0.33	1.81	218.8	1.31	7.1
48.	5.52	1.00	3.59	0.91	0.12	0.050	25.45	69.1	0.07	0.55	132.1	1.28	59.42
49.	4.97	2.79	3.12	0.32	0.10	0.140	41.69	81.0	0.4	0.69	248.5	1.58	4.25
50.	4.56	2.96	2.56	1.00	0.12	0.148	8.18	55.8	0.1	0.58	178.6	2.34	12.75
Mean (n=50)	4.91	1.90	2.87	0.58	0.15	0.09	43.97	66.53	0.36	0.85	134.15	1.27	16.31
Range	4.05-6.00	0.38-4.13	1.05-7.96	0.19-1.45	0.02-0.42	0.019-0.206	8.18-56.65	9.0-28.2	0.03-0.85	0.10-3.46	45.07-248.5	0.22-2.63	0.16-81.95
SD	0.34	0.80	1.18	0.40	0.11	0.04	32.39	16.82	0.18	0.80	54.90	0.58	20.31

Table 3. Interpretation class of soil test value for different nutrients in the Old Himalayan Piedmont Plain (AEZ 1) soils in relation to critical limit (FRG, 2012) (n = 50)

Interpretation class of macronutrients based on critical limit (FRG, 2012)	Macronutrient										
	N	P	K	S	Ca	Mg	Zn	B	Cu	Mn	Fe
Very low	47%	nil	20%	nil	nil	nil	40%	16%	0%	12%	nil
Low	49%	22%	65%	31%	62%	80%	30%	26%	2%	6%	nil
Medium	4%	4%	4%	63%	Nil	12%	8%	34%	4%	nil	nil
Optimum	nil	12%	8%	6%	2%	6%	6%	14%	2%	10%	nil
High	nil	28%	4%	nil	2%	Nil	8%	6%	8%	4%	nil
Very high	nil	37%	nil	nil	2%	2%	8%	4%	84%	68%	100%

Correlation study: An attempt was taken to examine the relationship of micronutrients with other soil variables and the interrelationship among micronutrients in soils (Table 4). It appears that the soil Cu exhibited significant relationship with pH (r=0.363**) organic matter (r=0.532**), available S (r=0.473**), B (r=0.363**) and Fe (r=-0.333**) and exchangeable Mg (r=0.674**). The available Zn was significantly correlated with available P (r=0.431**) and exchangeable K (r=0.366*). Soil available Mn was significantly associated with soil available S (r=0.397**), exchangeable K (r=0.303*), and Mg (r=0.334*). Soil available B did not show significant relationship with any soil variables. In a study Sidhu and Sharma (2010) reported that the available micronutrients (Zn, Cu, Mn and Fe) increased with increase in organic carbon and decreased with increase in sand content, pH, and calcium carbonate. Concerning interrelationship among micronutrients, only soil Cu showed significant relationship with available B (r=0.999**) andFe(r=-0.333*).Fe showed negative correlation with soil B concentration (r=-0.350*). It is well agreed that micronutrient availability in soils decreases as soil pH increases. This has not been reflected in the present study. So, unlikely soil B (r=0.281*) and Cu showed significant positive correlation (r=0.363**) with soil pH and Mg, respectively. Magnesium was found to be deficient in the coarse-textured soils of Old Himalayan Piedmont plain, Brown hill soils, and Grey floodplain soils of the northern part of the country (Islam *et al.,* 1992). The magnitude of deficiency level might increase due to decalcification and acidification processes (Ahsan and Karim, 1988).

Zinc: Available Zn in the soil samples varied from 0.10-3.46 mg kg^{-1} with the mean value 0.85±0.80 mg kg^{-1} (Table 2). On the basis of critical limit (0.60 mg kg^{-1}) suggested by FRG- 2012, the soil samples was found to be 30% low, 40% very low, 8% medium, 6% optimum, 8% high and 8% very high in availability of Zn status (very low $\leq$0.45, low 0.451-0.90, medium 0.91-1.35, optimum 1.351-1.80, High 1.81-2.25, Very high $\geq$2.25 mg kg^{-1}). A 49% soil samples were found below critical limit of Zn content.

Boron: All the nine 'soil series' samples had available B below 1.00 mg kg^{-1} and 16% soil samples were found below 0.20 (CL) mg kg^{-1} available B (Table 2). Havlin *et al*. (2010) mentioned that the total B content of soils lies between 2 and 200 mg kg^{-1} with the available B fraction ranging from 7 to 80 mg kg^{-1}. On the basis of critical limit suggested by FRG (2012), 16% soil samples were found very low, 26% low, 34% medium, 14% optimum, 6% high and 4% soil were found very high in available B (Very low $\leq$0.15, Low 0.151-0.30, medium 0.31-0.45, optimum 0.451-0.60, high 0.61-0.75, very high ≥ 0.75 mg kg^{-1}). Among soil samples, the available B ranged from 0.030-0.850 mg kg^{-1} with mean value 0.360±0.180 mg kg^{-1} (Table 2). This results were supported by Yau and Ryan (2008) who said that most soils have low B contents (<10 mg kg^{-1}), high B content soils are associated with use of irrigation water containing excess B.

Copper: Available Cu content of the soil samples varied from 0.22 to 2.63 mg kg^{-1} with the mean value of 1.27±0.58 mg kg^{-1} (Table 2). The data indicated that the Cu status of 84% soil samples were very high in availability considering critical limit. Gupta (2007) suggested that clay type soils are least likely to be Cu deficient. In soil solution with pH values below 6.9, the divalent ion Cu^{+2} is the dominant form of this element.

Manganese: Manganese in the soil samples varied from 0.16-81.95 mg kg^{-1} with the mean value of 16.32±20.31 mg kg^{-1}. Considering critical limit (1.00 mg kg^{-1}), 68% soil samples were found very highand 12% samples were very low in available Mn (Table 2).

Iron: Data on available Fe in soil samples indicated that 100% soil samples were very high in Fe concentration comparing 4.0 mg kg^{-1} as the critical limit proposed by FRG (2012). The DTPA- Fe in soils varied from 45.07-248.50 mg kg^{-1} with an average mean value of 136.88±54.90 mg kg^{-1} (Table 2). Iron comprises about 5% of the earth's crust and is the fourth most abundant element in the lithosphere (Rudnick and Gao, 2003) and soils rarely contain less than 0.70% Fe by weight (Shenker and Chen, 2005). Singh (2008) reported that the analyzed soil samples in India indicated that 49% of soils are potentially deficient in Zn, 12% in Fe, 5% in Mn, 3% in Cu, 33% in B.

Table 4. Correlation matrix among soil variables (n=50)

Soil variables	pH	OM	Total N	P	K	S	Ca	Mg	Available micronutrients				
									B	Zn	Fe	Cu	Mn
pH	1.000	0.153^{ns}	-0.109^{ns}	0.243^{ns}	0.530**	0.281*	0.525**	0.558*	0.281*	0.155^{ns}	-0.124^{ns}	0.363**	0.177^{ns}
OM		1.000	0.732**	-0.092^{ns}	0.017^{ns}	-0.455**	-0.268**	0.363**	0.283*	0.155^{ns}	-0.124^{ns}	0.532**	-0.264^{ns}
Total N			1.000	-0.160^{ns}	-0.028^{ns}	-0.143^{ns}	-.0.142^{ns}	-0.111^{ns}	-0.253^{ns}	-0.038^{ns}	0.420**	-0.187^{ns}	-0.215^{ns}
P				1.000	0.521**	0.001^{ns}	0.119^{ns}	0.157^{ns}	-0.067^{ns}	0.431**	-0.217^{ns}	0.055^{ns}	0.303^{ns}
K					1.000	0.139^{ns}	0.339*	0.355*	0.284*	0.366**	0.005^{ns}	0.062^{ns}	0.303*
S						1.000	0.496**	-0.047^{ns}	0.319*	0.246^{ns}	0.229^{ns}	-0.473**	0.397**
Ca							1.000	0.270^{ns}	0.340*	0.065^{ns}	0.056^{ns}	0.124^{ns}	0.091^{ns}
Mg								1.000	0.104^{ns}	0.194^{ns}	-0.116^{ns}	0.674**	0.334*
Available micronutrients													
B									1.000	-0.085^{ns}	-0.350^{ns}	0.999**	-0.104^{ns}
Zn										1.000	0.226^{ns}	-0.091^{ns}	0.344*
Fe											1.000	-0.333*	0.060^{ns}
Cu												1.000	-0.109^{ns}
Mn													1.000

**and ** significant at P=0.05 and P=0.01, respectively.*

Conclusion

The bench line survey in AEZ 1 indicated that the zinc status of soils was 'very low' to 'low'; the soil B status was 'low' to 'medium'based on the interpretation of soil test values in relation to critical limit of the nutrient. The status of other micronutrients such as Cu, Mn and Fe was generally 'very high'. Study of micronutrients status in the soils revealed the micronutrient deficiency in the order of Zn> B> Mn> Cu> Fe. About 70% soils are deficient in Zn and 42% soils in B. About 49%, 22%, 65%, 31%, 62% and 80% soil samples were found 'low' in N, P, K, S, Ca and Mg status. It is well established that micronutrient availability in soils decreases as soil pH increases. But this has not been reflected in the present study. So, unlikely soil Cu and B showed significant positive correlation with soil pH. The reason can be attributed to the narrow and strongly acid pH range of soil samples.

References

Ahsan, E. and Karim, Z. 1988. Soil and management research on upland soils of Bangladesh. In: "Proceedings of the International Conference on the Management and Fertilization of Upland Soils in the Tropics and Subtropics," pp. 247-251.

Bell, R.W. and Dell, B. 2008. Micronutrients for Sustainable Food, Feed, Fibre and Bioenergy Production. First edition, IFA, Paris, France (www.fertilizer.org). pp. 53-55.

Fageria, V.D. 2001. Nutrient Interactions in Crop Plants. J. Plant Nutri. 24(8): 1269-1290.

FRG (Fertilizer Recommendation Guide) 2012. BARC (Bangladesh Agricultural Research Council), Farmgate, Dhaka. p. 33.

Gupta, P.K. 2007. A Handbook of Soils, Ferlizeranm Manure, 2nd edn. AGROBIOC (India).

Havlin, J.L., Beaton, J.D., Tisdale, S.L. and Nelson, W.L. 2010. Soil Fertility and Fertilizers: an introduction to nutrient management. PHI Learning Pt. Ltd., New Delhi, India. pp. 26-37.

Hossain, M.A. 2012. Land Resources Appraisal and Crop Management in Bangladesh. Crop & Environ. 3: 67-70.

Islam, M.S., Amin, M.S. and Anwar, M.N. 1992. Integrated soil fertility management in Bangladesh.In "Proceedings of the Inter-Congress Conference of Commission IV of ISSS on Improving Soil Management for Intensive Cropping in the Tropics and Sub-Tropics." Hussain, M.S., Huq, S.M.I., Iqbal, M.A., Khan, T.H. (Editors). pp. 147-156.

Jackson, M.L. 1967. Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd. New Delhi. pp. 25-39.

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

Jahiruddin, M., Hoque, M.S., Hoque, A.K.M.M. and Roy, P.K. 1992. Influence of boron, copper and molybdenum on gram formation in wheat. Crop Res. 5: 35-42.

Keren, R. 1996. Boron. *In:* Methods of Soil Analysis. Part 3. Chemical methods-Soil Science Society of America Book Series no. 5, Sparks, D. L. (Editor), Madison, Wisconsin: SSSA and ASA pp. 603-326.

Kizilgoz, I. and Sakin, E. 2010. The effects of increased phosphorus application on shoot dry matter, shoot P and Zn concentrations in wheat (Triticum durum L.) and maize (*Zea mays* L.) grown in a calcareous soil. African J. Biotech. 9(36): 5893-5896.

Lindsay, W.L. and Norvell, W.A. 1978. Development of a DTPA soil test for zinc, iron, manganese, and copper. Soil Sci. Soc. America J. 42(3): 421-428.

Mondal, M.H.R., Jahiruddin, M., Rahman, M.M. and Hashem, M.A. 1991. An investigation on nutrient requirements for BR11 rice in Old Brahmaputra Floodplain soil. Bangladesh J. Crop Sci. 2: 23-30.

Moslehuddin, A.Z.M., Laizoo, S. and Egashira, E. 1997. Fertility Status of Bangladesh Soils -A Review. J. Fac. Agric., Kyushu Univ. 41(3-4): 257-267.

Mukhopadhayay, D., Eunus, M. and Huq, M.M. 1986. Response of major crops to balanced fertilizer application. Department of Agricultural Extension, Food and Agriculture Organization, Dhaka, Bangladesh. pp. 42-48.

Portch, S. and Islam, M.S. 1984.Nutrient status of some of the more important agricultural soils of Bangladesh. In “Proceedings of International Symposium on Soil Test Crop Response Studies” Bangladesh Agricultural Research Council and Soil Science Society of Bangladesh. pp. 97-106.

Potash and Phosphate Institute. 1983: *In:* Soil Fertility Manual. Potash and Phosphate Institute, Atlanta, USA. p. 37

Rudnick, R.L. and Gao, S. 2003. The Composition of the Continental Crust. *In:* Holland, H.D. and Turekian, K.K., Eds., Treatise on Geochemistry, Vol. 3, The Crust, Elsevier-Pergamon, Oxford, 1-64. http://dx.doi.org/10.1016/b0-08-043751-6/03016-4.

Shenker, M. and Chen, Y. 2005. Increasing iron availability to crops: fertilizers, organo-fertilizers and biological approaches. Soil Sci. Plant Nutr. 51(l): 1-17.

Sidhu, G.S. and Sharma, B.D. 2010. Diethylenetriaminepentaacetic acid-extractable micronutrients status in soil under a rice-wheat system and their relationship with Soil properties in different agro-climatic zones of Indo-Gangetic Plains of India. Commun. Soil Sci. Plant Anal. 41(1): 29-51.

Singh, M.V. 2008. Micronutrient deficiencies in crops and soils in India. Micronutrient deficiencies in global crop production, pp.93-125.

Uddin, M.J., Hasan, M.K., Mohiuddin, A.S.M., Ahmed, S.U. and Hassan, M.M. 2012. Study on some soils of the Himalayan Piedmont Plain of Bangladesh. J. Asiatic Soc. Bangladesh Sci. 38(2): 199-206.

Yau, S.K. and Ryan, J. 2008. Boron toxicity tolerance in crops: a viable alternative to soil amelioration. Crop Sci. 48: 854-865.

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PHOTOSYNTHESIS, DRY MATTER PARTITIONING AND YIELD OF MUNGBEAN UNDER HIGH TEMPERATURE

M. T. Islam

Abstract

Two pot experiments were conducted to evaluate summer mungbean genotypes during March to May 2010 and 2011 at BINA, Mymensingh, Bangladesh under high temperature at different growth stages. Eight mungbean varieties *viz*. Binamoog-2, Binamoog-5, Binamoog-6, Binamoog-7, BARI Mung-2, BU mung-1, BU mung-2 and BU mung-4 were used in this study. Temperature treatments *viz*., (i) Ambient, (ii) 36^{0}C at pre-flowering, (iii) at flowering and (iv) at pod filling stages were imposed for 7 days in a controlled plant growth chamber (RH 80%, CO_2 330 ppm). High temperature (36^{0}C) at pre-flowering, flowering and pod filling stages decreased photosynthetic rates, lower leaf conductance at pre-flowering stage but identical transpiration rate at all stages. The highest dry matter plant^{-1} was found at ambient and the lowest at high temperature at flowering stage. Similarly, the highest yield was recorded at ambient temperature but high temperature showed identical yields at all stages. High temperature at all the growth stage decreased stem weights significantly.

Key words: Growth stage, Mungbean yield, Photosynthesis, Temperature

Introduction

Mungbean (*Vigna radiata* L. Wilczek) is one of the most important crops of global economic importance. It is prized among the pulse species for its seeds are high in essential dietary protein, easily digested and low production of flatulence when consumed as food (Lakhanpaul *et al*., 2000). It has yield potential of around 2000 kg ha^{-1} but productivity is low 842 kg ha^{-1} (BBS, 2016). There are many reasons for such low yield: the varieties grown are generally low yield potential, susceptible to pests and diseases, 70-90% of flowers do not develop into mature pods, less responsive to high inputs and limiting sources (Kuo *et al*., 1978). Number of pods and seeds is related with photosynthetic rate that determines through leaf area and dry matter production. Per cent solar radiation interception and rate of dry matter production increased with leaf area development (Hamid *et al*., 1990). In order to improve the production potential, selection of genotypes based on their leaf photosynthetic rates has been practiced in peas (Mahon and Hobbs 1981). Mungbean yield is predetermined by the potential of a given variety and the environment. Optimum temperature for potential yield of mungbean lies between 28-30^{0}C (Poehlman, 1991). High temperature affects yield in mungbean (Khattak *et al*. 2009). In Bangladesh, mungbean is

Crop Physiology Division, Bangladesh Institute of Nuclear Agriculture, BAU Campus, Mymensingh-2202, Bangladesh.

cultivated in winter and summer and both low and high temperature affects its growth and yield. Summer varieties are often facing high temperature (34-38^{0}C) during April-May. But information regarding their tolerance to high temperature is less. If physiological basis of yield and yield-forming components under such temperature stress are understood, it is possible to improve yields of a mungbean crop. So, effect of temperature at different growth stages of eight mungbean varieties was investigated with respect to photosynthesis, dry matter partitioning, yield attributes and yield.

Material and Methods

Two pot experiments were conducted to evaluate summer mungbean genotypes during March to May 2010 and 2011 at BINA, Mymensingh, Bangladesh. Eight mungbean varieties *viz*. Binamoog-2, Binamoog-5, Binamoog-6, Binamoog-7, BARI Mung-2, BU mung-1, BU mung-2 and BU mung-4 were used in this study. Each pot contained 8 Kg of soils (Silty loam, organic matter 1.05%, total N 0.07%, available P 14.3 ppm, exchangeable K 0.25 meq. per 100g soil, available S 13.2 and soil pH 6.67). The experiment was laid out in a Complete Randomized Design with three replications. Recommended dose of fertilizers was applied and other cultural practices were followed as and when required. Temperature treatments *viz*., (i) Ambient, (ii) 36^{0}C at pre-flowering, (iii) at flowering and (iv) at pod filling stages were imposed for 7 days in a controlled plant growth chamber (RH 80%, CO_2 330 ppm). Ambient temperature was recorded 27-32°C during pre-flowering, flowering and maturity stages of mungbean varieties. Photosynthesis, leaf conductance and transpiration rate were recorded using *Portable Photosynthesis System LI-6400XT, LI-COR Inc.,* Lincoln, NE, USA. Partitioning of dry matter and yield attributes were taken at maturity. Statistical analysis was done as per design used with the help of MSTAT computer packages (Russell, 1986). Duncan's Multiple Range Test (DMRT) was used to compare the means at 5% level of significance.

Results and Discussion

High temperature (36^{0}C) at pre-flowering, flowering and pod filling stages decreased photosynthetic rates (Table 1). Leaf conductance decreased at pre-flowering stage but remained unchanged at flowering and pod filling stages. Transpiration rate was not affected by the temperature treatments. Root weight plant^{-1} was affected by the high temperature at pre-flowering and flowering stages compared to ambient temperature (Table 2). But high temperature at pod filling stage did not affect root weight. The highest stem weight was found at ambient temperature and the lowest at the temperature at flowering stage. Higher leaf weight was recorded at ambient and the high temperature (36^{0}C) at pre-flowering stage. High temperature at pre-flowering, flowering and pod filling stages decreased pod weight compared to ambient. The highest dry matter plant^{-1} was found at ambient and the lowest at high temperature at flowering stage. Higher number of pods plant $^{-1}$ was observed at ambient and high temperature (36^{0}C) at pod filling stage (Table 3). Higher number of seeds pod^{-1} was noticed at high temperature at flowering than pod filling stage. Maximum 1000-seed weight was found at ambient temperature and minimum at the high temperature at pod

Table 1. Effect of high temperature on photosynthesis, leaf conductance and transpiration rate of eight mungbean varieties

Treatment	Photosynthetic rate ($\mu molCO_2m^{-2}s^{-1}$),	Leaf conductance ($molH_2Om^{-2}s^{-1}$)	Transpiration rate ($molH_2Om^{-2}s^{-1}$)
Temperature			
Ambient (control)	26.21a	0.25a	3.72a
36 ^{0}C at pre-flowering stage	23.99b	0.24b	3.71a
36 ^{0}C at flowering stage	23.85b	0.25a	3.70a
36 ^{0}C at pod filling stage	23.96b	0.25a	3.71a
Varieties			
Binamoog-5	23.31de	0.22e	3.21f
Binamoog-6	23.53d	0.24d	3.40e
BU mung-1	27.35a	0.28a	4.44a
BU mung-2	26.14b	0.26b	4.13b
BU mung-4	25.59c	0.25c	3.91c
BARI Mung-2	23.59d	0.24d	3.75d
Binamoog-2	23.55d	0.24d	3.43e
Binamoog-7	23.08e	0.23e	3.39e
Year			
2010	24.39b	0.24b	3.69b
2011	24.64a	0.25a	3.73a
CV%	3.04	4.63	3.48

Table 2. Effect of high temperature at different growth stages on dry matter partitioning of eight mungbean varieties

Treatment	Root weight plant^{-1} (g)	Stem weight plant^{-1} (g)	Leaf weight plant^{-1} (g)	Pod weight plant^{-1} (g)	Total dry matter plant^{-1} (g)
Temperature					
Ambient (control)	1.54a	10.39a	4.68a	13.45a	30.08a
36 ^{0}C at pre-flowering stage	1.43b	7.51b	4.63a	10.58b	24.16b
36 ^{0}C at flowering stage	1.41b	6.54c	4.07b	10.59b	22.63c
36 ^{0}C at pod filling stage	1.50a	7.80b	4.17b	10.87b	24.35b
Varieties					
Binamoog-5	1.64a	8.53ns	4.59ns	12.60a	27.36a
Binamoog-6	1.48cd	8.17	4.43	11.71b	25.81b
BU mung-1	1.29f	7.64	4.18	10.75c	23.88c
BU mung-2	1.34ef	7.70	4.39	10.84c	24.14c
BU mung-4	1.40de	7.81	4.35	10.77c	24.38c
BARImung-2	1.48cd	8.07	4.49	10.88c	24.78bc
Binamoog-2	1.55bc	8.22	4.41	11.60b	25.87b
Binamoog-7	1.58ab	8.35	4.43	11.83b	26.19ab
Year					
2010	1.45b	8.86a	3.61b	11.56a	25.50
2011	1.49a	7.26b	5.16a	11.18b	25.10
CV%	9.13	15.55	21.29	10.66	8.96

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

filling stage. Ambient temperature showed the highest yield. Yields at high temperature at pre-flowering, flowering and grain filling stages were statistically identical. Binamoog-5 produced the highest root weight, pod weight, total dry matter, yield plant^{-1} and lower photosynthetic rate, leaf conductance and transpiration rate. Binamoog-6 showed identical number of pods and yield plant^{-1} to Binamoog-5. BU mung-1 had the highest photosynthetic rate, leaf conductance, transpiration rate, number of seeds pod^{-1} and lower root weight, pod weight, number of pods, total dry matter and seed yield plant^{-1}. BU mung-2 produced the highest number of seeds pod^{-1} and lower root weight, pod weight, total dry matter and yield plant^{-1}. BU mung-4 and BARI Mung-2 showed medium photosynthetic rate, leaf conductance, transpiration rate, root weight, pod weight, total dry matter and seed yield plant^{-1} with lower number of seeds pod^{-1}. Binamoog-2 and Binamoog-7 had lower photosynthetic rate, transpiration rate, medium root weight, pod weight, total dry matter and seed yield plant^{-1} with higher number of pods plant^{-1}.

Table 3. Effect of high temperature at different growth stages on yield attributes and yield of eight mungbean varieties

Treatment	Pods plant^{-1} (no.)	Seeds plant^{-1} (no.)	1000-seed weight (g)	Yield plant^{-1} (g)
Temperature				
Ambient (control)	29.43a	5.32ab	43.10a	11.17a
36 ^{0}C at pre-flowering stage	28.29b	5.34ab	39.58b	8.31b
36 ^{0}C at flowering stage	27.95b	5.45a	39.56b	8.34b
36 ^{0}C at pod filling stage	30.02a	5.16b	36.45c	8.47b
Varieties				
Binamoog-5	30.37ab	5.10b	40.29	10.01a
Binamoog-6	30.12ab	5.15b	39.37	9.49ab
BU mung-1	23.04d	5.76a	39.70	8.60d
BU mung-2	26.41c	5.67a	39.83	8.64d
BU mung-4	29.54b	5.26b	39.54	8.68d
BARImung-2	30.41ab	5.23b	39.37	8.77cd
Binamoog-2	30.79a	5.15b	39.83	9.09bcd
Binamoog-7	30.70a	5.22b	39.45	9.30bc
Year				
2010	28.85b	5.10b	39.24b	9.23a
2011	29.00a	5.53a	40.11a	8.92b
CV%	5.81	12.10	4.31	10.15

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

High temperature (36^{0}C) at pre-flowering, flowering and pod filling stages decreased seed yield due to mainly by reducing 1000-seed weight and number of pods per plant. High temperature may cause flowers dropping due to some hormonal changes or failure in fertilization. The failure in hybridization could be due to the indehiscence of anthers or drying up of stigma and ovary of the flowers due to high temperature. Failure in hybridization due to the indehiscence of anthers in cowpea and drying up of stigma and overy of the flower in mungbean due to high temperature were reported by Khattak *et al*. 1998. They also reported that mungbean plants produce large number of flowers but drops up to 60% prior to pod initiation. High temperature during flowering causes huge flowers' sheding. Genetic differences for number of flowers produced in mungbean have been reported (Kumari and Varma, 1983; Khattak, 2006) but genetic tolerance for flowers' sheding under high temperature is absent in the existing germplasm of this crop (Khattak, 2006). Temperature 36^0C at pre-flowering stage affected photosynthesis, root, stem and pod development and total dry matter production. The results are in agreement with those of Karim *et al*., 2003; Vijaylami and Bhattacharya, 2007 and Sharma *et al*., 2016. Temperature stress (36^0C) at pod filling stage affected number of seeds pod^{-1} and grain development, remaining the number of pods $plant^{-1}$ identical. Photosynthesis has generally considered being the primary factor affecting the dry matter production in crop plants. The dry matter production and its subsequent conversion into economic yield are the result of a complex physiological process within plants. In mungbean, seed yield has been reported to be significantly related to the leaf photosynthetic rates of the crop at early pod development stage, whereas, there was no significant relationship between the two parameters at vegetative stage (Srinivasan *et al*., 198; Islam and Razzaque, 2010). Tolerance to abiotic stresses is very complex at the cellular levels of the whole plant (Foolad *et al*., 2003). This is in part due to the complexity of interactions of between factors and various molecular, biochemical and physiological phenomena affecting plant growth and development (Zhu, 2001).

Conclusion

High temperature (36^0C) decreased grain yield of all the eight studied mungbean varieties at all the stages studied.

References

BBS. 2016. Bangladesh Bureu of Statistics. Ministry of Planning. Government of the People's Republic of Bangladesh. p. 107.

Foolad, M.R., Zhang L. and Subbiah. 2003. Genetics of drought tolerance during seed germination in tomato: inheritance and QTL mapping. Genope 46: 536-545.

Hamid, M. A., Agata, W. and Kawamitsu, Y. 1990. Photosynthesis, transpiration and water use efficiency in four cultivars of mungbean. Photosynthetica 24: 96-101.

Islam, M.T. and Razzaque, A.H.M. 2010. Relationships of photosynthetic related parameters and yield of summer mungbean varieties/mutants. Int. J. Sustain. Crop Prod. 4: 11-15.

Karim, A, Fukamachi, H. and Hidaka, T. 2003. Photosynthetic performance of *Vigna radiata* L. leaves developed at different temperature and irradiance levels. Plant Sci. 164:454-458.

Khattak, G.S.S., Haq M.A., Rana, S.A., Elahi, T. and Srinives, P. 1998. An efficient technique for crossing mungbean (*Vigna radiata* L. Wilczek). Thai J. Agril. Sci. 31(4): 577-582.

Khattak, G.S.S., Saeed, I. and Muhammad, T. 2006. Breeding for heat tolerance in mungbean (*Vigna radiata* L. Wilczek). Pak. J. Bot. 38(5): 1539-1550.

Khattak, G.S.S., Saeed, I. and Muhammad, T. 2009. Breeding for abiotic stresses in mungbean (*Vigna radiata* L. Wilczek). Pak. J. Bot. 41: 35-39.

Kumari, P. and Varma, S.K. 1983. Genotypic differences in flower production/sheding and yield in mungbean. Indian J. Plant Physiol. 26: 402-405.

Kuo, C.G., Jung, M.C.H. and Tsou, C.S. 1978. Translocation of ^{14}C photosynthesis in mungbean during the reproductive period. Hort Sci. 13: 580-581.

Lakhanpaul, S., Chadha, S. and Bhat, K.V. 2000. Random amplified polymorphic DNA (RAPD) analysis in Indian mungbean (*Vigna radiata* (L.) Wilczek) cultivars. Genetica 109(3): 227-234.

Mahon, J.D. and Hobbs, L.A. 1981. Selection of peas for photosynthetic CO_2 exchange rate under field conditions. Crop Sci. 21: 616-621.

Poehlman, J.M. 1991. The Mungbean, Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi. pp. 27-30.

Russell, D.F. 1986. MSTAT-C. Crop and Soil Sciences Department, Michigan State University, USA.

Sharma, L., Priya, M., Bindumadhava, H., Nair, R.M., Harsh Nayyar, H. 2016. Influence of high temperature stress on growth, phenology and yield performance of mungbean [*Vigna radiata* (L.) Wilczek] under managed growth conditions. Scientia Hort. 213: 379-391.

Srinivasan, P.S.R., Chandrababu, Natarajaratnam N and Rangaswamy S.R.S. 1985. Leaf photosynthesis and yield potential in green gram (*Vigna radiata* (L.) Wilczek) cultivars. Tropic. Agric. Trinidad. 62: 222-224.

Vijaylami and Bhattacharya 2007. Mungbean seed yield: Effect of dry matter yield under drought conditions. Plant Cell Environ. 25: 333-341.

Zhu, J.K. 2001. Plant salt tolerance. Trends Plant Sci. 6: 66-71.

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GROWTH AND SEED YIELD RESPONSE OF SESAME TO SOWING DATES

M. J. Alam[1], M. M. A. Mondal[2] and M. M. Rahman[1]

Abstract

An experiment was conducted at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh, during February to June 2014 to investigate the effect of dates of sowing on crop characters, yield attributes and yield of sesame. The experiment comprised of three sesame varieties *viz.*, Binatil-1, BARI Til-2 and BARI Til-3 and five dates of sowing *viz.*, 26 February, 13 March, 28 March, 12 April and 27 April. The experiment was laid out in a split-plot design with three replications. Results revealed that plant height, branch, leaf and node number plant^{-1}, stem, shell and stover weight plant^{-1} and harvest index, yield attributes *viz.*, capsule number plant^{-1}, capsule length, seed number capsule^{-1}, 1000-seed weight and yield decreased with delay in sowing and yield became zero when sown in April due to death of plants at early growth stages for heavy rainfall in May and June. The highest seed yield was observed when seeds sown in 26 February due to attributed higher number of capsules plant^{-1} and seeds capsules^{-1}. The lowest seed yield was recorded in 28 March sowing. Among the cultivars, the highest seed yield was recorded in Binatil-1 (900 kg ha^{-1}). Results indicated that higher sesame yield can be obtained by sowing of Binatil-1 and BARI Til-3 on 26 February while BARI Til-2 on 13 March.

Key word: Sowing date, growth, sesame.

Introduction

Sesame (*Sesamum indicum* L.) is an important oilseed crop in Bangladesh and is grown almost all regions in the country. It is the third largest source of edible oil in the country. Among the areas of oil crops, rapeseed/mustard, groundnut and sesame occupied 70, 18 and 12%, respectively of the total cropped area (MOA, 2016). The crop is grown both in summer and winter seasons in Bangladesh. The summer sesame covers about two-third of the total cropped area. The seeds of sesame contain 44-56% oil, 18-22% protein and 15-20% carbohydrate (Weiss, 1983). Sesame oil is mainly used for cooking and also used in the manufacture of perfumes, pharmaceuticals and insecticides (Sarker *et al.*, 2007). Hulled seed is used in baking industries. Sesame oil cake contains protein of high biological value and appreciable quantities of calcium and phosphorus and is used as a very good animal feed and fertilizer. Oilseed crops play a vital role in human diet but the consumption rate is far below the balanced diet. To fulfill the requirement, the country has to increase its production to meet its internal demand. The area under oilseed crop may be increased for boasting its production with the adoption of appropriate technologies.

[1] Department of Agronomy, Bangladesh Agricultural University, Mymensingh-2202
[2]Crop Physiology Division, Bangladesh Institute of Nuclear Agriculture, BAU Campus, Mymensingh-2202

Despite its versatile use and wide adaptability to the agro-environmental conditions of Bangladesh, the crop is still neglected both in the research and farmers levels. The climate and edaphic conditions of Bangladesh are quite suitable for its cultivation but contribution of sesame to total production is lesser due to its lower yield (680 $kgha^{-1}$; MOA, 2015). The low yield of sesame is primarily due to poor management practices (Mia *et al*., 2015). Successful production of the crop depends on quality seed and appropriate management practices. Among the various management practices, time of sowing is the single most important factor influencing the yield of sesame. Reports reveal that seed yield decreases both with delay or early planting than optimum date (Sivagamy and Rammohan, 2013). However, optimum planting time varies in different regions of Bangladesh depending upon onset of monsoon and specific photo-thermal requirement (Sarker *et al*., 2007). Research works on the effect of time of sowing on sesame are scanty. Sarkar *et al.* (2007) reported that last week of February sowing was best suited for getting maximum yield in sesame. On the other hand, Shubha (2006) reported that March sowing gave the highest seed yield in sesame. So, further research work is necessary to find out appropriate sowing date of sesame. Considering the above background, the present study was undertaken to find out the effect of date of sowing on crop characters, yield and yield attributes of sesame; and to observe the interaction effect of sowing date and cultivar on crop characters, yield and yield attributes of sesame.

Materials and Methods

The experiment was carried out at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from 26 February to 17 June 2014. The experimental field was medium high land belonging to the Sonatola Soil Series of Grey Floodplain soil under the Old Bahmaputra Floodplain Agro-ecological Zone (AEZ-9). The soil was silty loam. The experimental field is under subtropical climate characterized by heavy rainfall during the month of April to September and scanty rainfall during October to March. The maximum, minimun and average temperature range during the experimental period (February to June) are presented in Table 1.

The experiment comprised of three sesame varieties *viz.*, Binatil-1, BARI Til-2 and BARI Til-3 and five dates of sowing *viz*., 26 February, 13 March, 28 March, 12 April and 27 April. The experiment was laid out in a split-plot design with three replications. Date of sowing was assigned to main plot and variety to the sub-plot. The size of the unit plot was 3.0 m × 3.0 m. Plant to plant and row to row distances were maintained at 5 cm and 30 cm, respectively. Urea, triple super phosphate (TSP), muriate of potash (MP), gypsum and zinc sulphate were applied at 100, 130, 50, 100 and 5 kg ha^{-1} (BARI, 2014). Total amount of TSP, MP, gypsum, borax and half of urea were applied as basal dose while remaining half urea was top dressed at 25 days after sowing. Only one weeding was done manually at 15 days after sowing for each date of sowing. Among the five dates of sowing, the latter two sowing dates i.e. 12 and 27 April, the crop died before reaching harvesting stage due to water logging by heavy rain. At maturity, harvesting was done only for the sowing dates of 26 February, 13 March and 28 March. Ten plants were randomly selected from each plot and tagged for recording necessary data. After sampling, the whole plot was harvested at maturity. The harvested crop was threshed, cleaned and sun dried to a moisture content of 14% to record the yields of grain and straw plot wise and converted into tons hectare^{-1}. The collected data were analyzed statistically following the analysis of variance (ANOVA) technique and the mean differences were adjudged by Duncan's Multiple Range Test (DMRT) using the statistical computer package program, MSTAT-C (Russell, 1986).

Results and Discussion

The crop sown on 26 February, 13 March and 28 March reached their maturity stage but the crops sown on 12 April and 27 April did not because they died at their vegetative stage due to water logging (Table 1).

Table 1. Monthly recorded of air temperature, rainfall, relative humidity and sunshine hours of the experimental site during the period from February to June, 2014

Months		Air temperature (^{0}C)			Total rainfall (mm)	Average relative humidity (%)	Total sunshine (hrs)
		Maximum	Minimum	Average			
February	01-07	24.21	13.74	18.97	0.00	80.57	6.90
	08-15	26.56	15.96	21.26	00.0	76.86	7.20
	16-22	27.00	14.81	20.91	0.10	72.00	9.06
	23-28	27.34	15.46	21.40	0.00	71.43	9.57
March	01-07	28.40	17.80	23.10	0.00	69.86	8.51
	08-15	26.50	16.40	21.45	19.0	75.63	6.63
	16-23	28.50	18.45	23.48	2.10	76.75	7.39
	24-31	29.44	20.02	24.73	92.9	78.63	7.14
April	01-07	30.41	20.33	25.37	0.00	78.86	7.46
	08-15	32.84	23.01	27.93	22.0	78.12	8.86
	16-22	30.56	22.14	26.35	51.8	82.57	6.04
	23-30	31.56	22.62	27.09	61.4	81.00	6.91
May	01-07	31.54	23.73	27.64	39.0	85.57	3.54
	08-15	32.80	23.71	28.25	20.4	77.25	7.95
	16-23	32.84	23.34	28.09	102	79.75	7.99
	24-31	32.55	23.50	28.03	104	82.50	6.29
June	01-07	32.54	24.73	28.64	35.0	87.50	5.54
	08-15	33.40	24.31	28.85	20.4	87.27	6.95
	16-23	33.84	24.54	29.19	112	79.75	7.99
	24-30	33.25	24.20	28.73	124	82.51	6.69

Source: Weather Yard, Department of Irrigation and Water Management, BAU, Mymensingh.

Effect of sowing date on morphological characters:

Results indicated that the plant height decreased with delay in sowing of all varieties (Fig. 1). The pattern of increase of plant height for the first two sowing was almost similar (Fig. 1). Although delayed sowing decreased plant height, it was very much severe for the

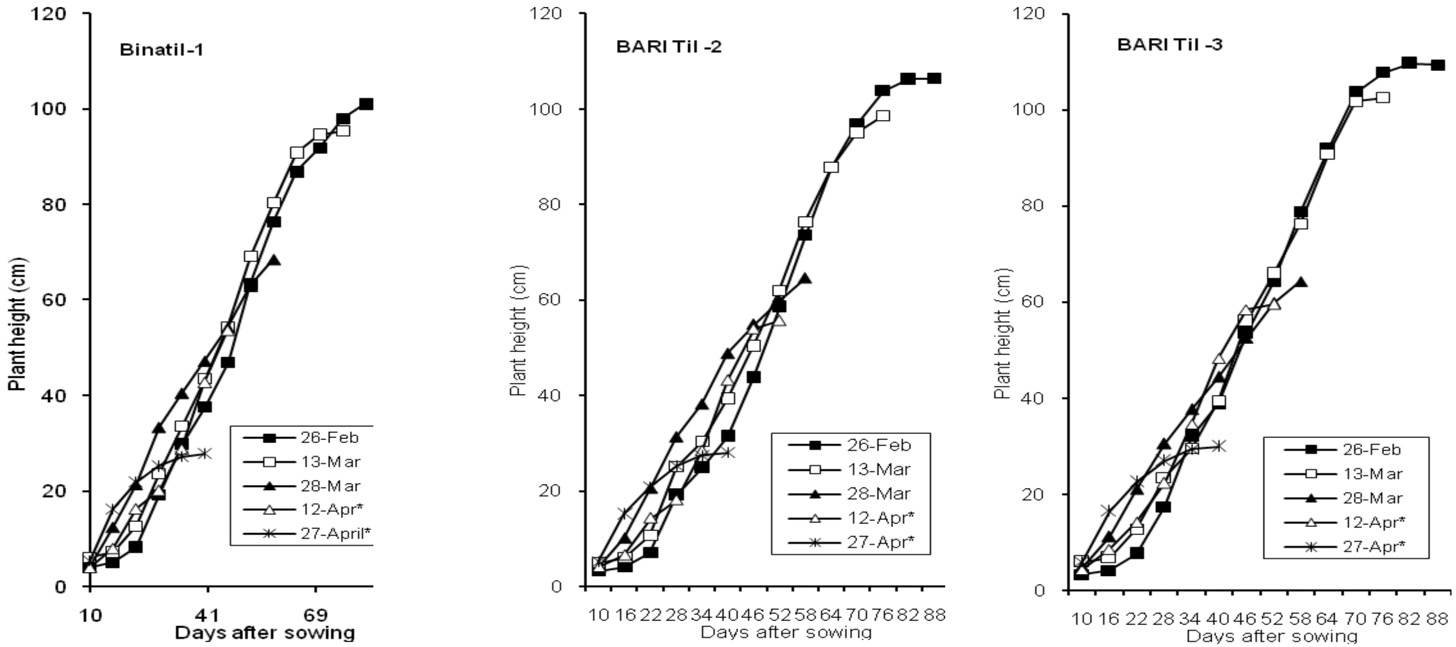

Fig. 1. Seasonal pattern of plant height of three sesame varieties *viz.*, Binatil-1, BARI Til-2 and BARI Til-3 under five date of sowing. (The crop sown on 12 and 27 April died at about 40 and 60 days after sowing, respectively)

last three sowings. The highest plant height was recorded in 26 February sowing (101.8 cm) followed by 13 March sowing (95.4 cm). The lowest plant height was observed in 27 April sowing (27.8 cm). Mentionable that 12 and 27 April sowing plants died before fruit setting due to heavy rainfall (Table 1). Similar result was also reported by Sarkar *et al.* (2007) in sesame where sesame genotypes were sown at three dates of sowing (26 Feb., 10 and 22 March) with in which plant height decreased with delayed sowing.

The number of leaves plant^{-1} increased slowly until 34 days after sowing (DAS) then increased rapidly up to 76-80 DAS and followed by declined at maturity (Fig. 2) due to leaf shedding. The number of leaves plant^{-1} decreased with delay sowing in all the cultivars. In Binatil-1, the highest number of leaves was recorded in 13 March of sowing followed by 26 February sowing. On the other hand, in BARI Til-2 and BARI Til-3, the highest number of leaves was recorded in 26 February sowing followed by 13 March sowing. The lowest number of leaves plant^{-1} was observed in 27 April sowing in all cultivars. Similar result was also reported by Ali *et al.* (2005) in sesame. He conducted an experiment to know the effect of sowing date (15 February, 1, 15 and 30 March) on sesame genotypes and reported that number of leaves plant^{-1} decreased with delay in sowing due to shorter plant stature.

The highest number of nodes plant^{-1} was found in 26 February sowing then decreased with delay in sowing due to shorter plant height (Fig. 3). The highest number of nodes plant^{-1} was observed in 26 February sowing in all varieties due to production of taller plant. In contrast, the lowest number of nodes plant^{-1} was recorded in plants from 27 April sowing in all the varieties. The lower number of nodes plant^{-1} was observed in delayed sowing that might be due to its growth retardation by the heavy rainfall that might have cause root rotten under saturated field condition (Sarkar *et al*., 2007).

The effect of date of sowing on stem, shell and stover weight was significant except harvest index (Table 2). Results indicated that stem, shell and stover weigh decreased with delay sowing. The highest number of branches and nodes plant^{-1} (23.55), the highest stem and stover weight was observed in 26 February sowing and the lowest was recorded in 28 March sowing (17.84) (Table 1).

Effect of variety on morphological characters:

The variation in number of branches and nodes plant^{-1}, stem and shell weight, and harvest index among the varieties was statistically significant except plant height and stover weight (Table 2). The highest number of nodes and branches plant^{-1}, the highest plant height, stem, shell and stover weight was recorded in BARI Til-2 followed by BARI Til-3. The lowest number of branches and nodes plant^{-1} was observed in Binatil-1. Variation in number of nodes and branches plant^{-1} could be related to varietal characteristics of the varieties. Binatil-1 produced fewer number branches plant^{-1} (Table 2) which resulted lower number of nodes plant^{-1}. The highest harvest index was observed in BINA til 1 which means that Binatil-1 has the better capacity to dry matter partitioning to economic yield which is the desirable character.

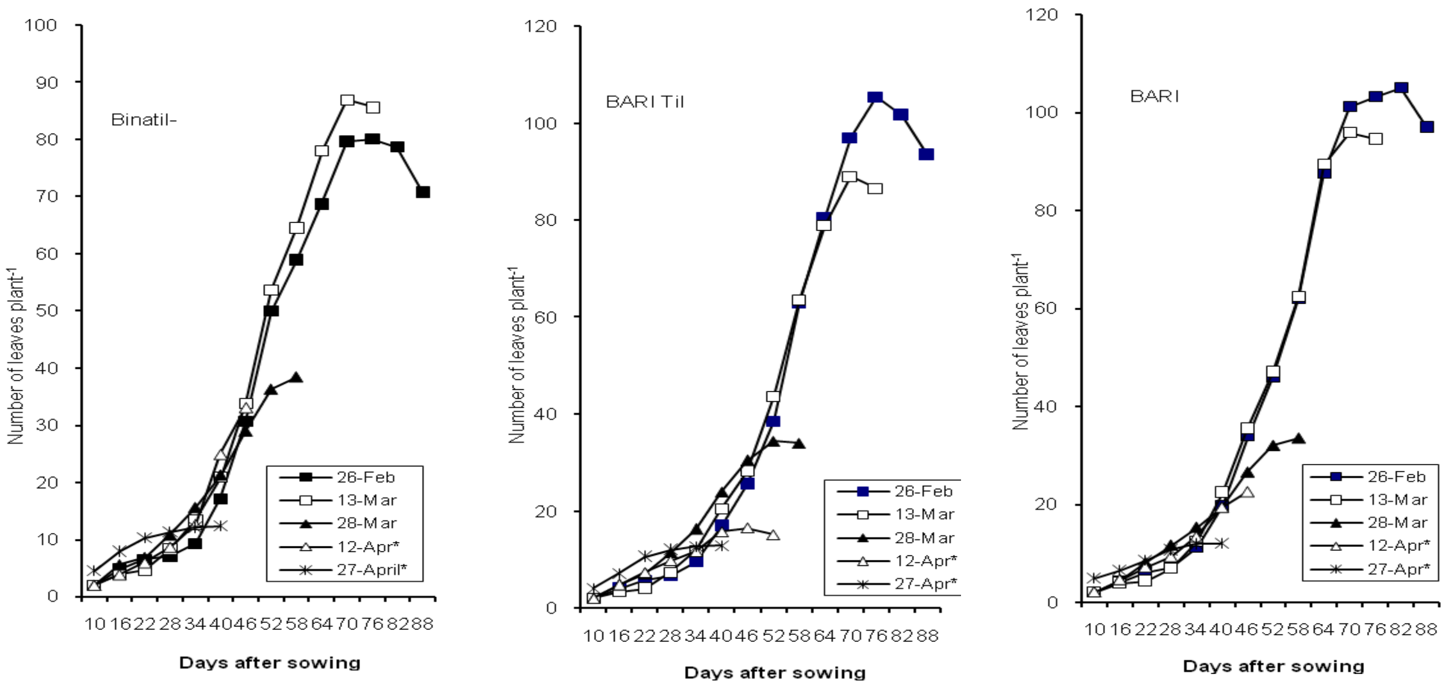

Fig. 2. Seasonal pattern of leaf production of three sesame varieties *viz*., Binatil-1, BARI Til-2 and BARI Til-3 under five date of sowing. (The crop sown on 12 and 27 April died at about 40 and 60 days after sowing, respectively)

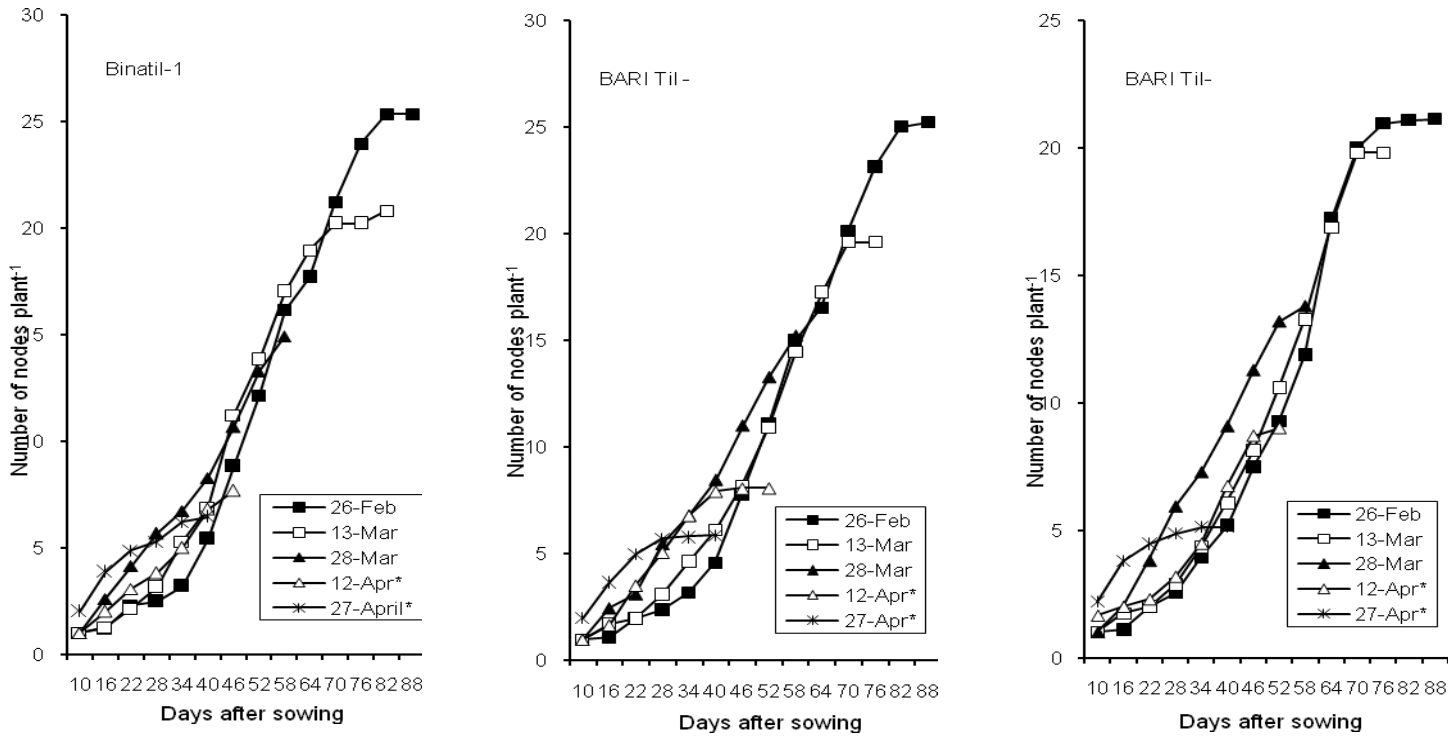

Fig. 3. Effect of date of sowing on node number at different growth stages of sesame cultivars *cv.* Binatil-1, BARI Til-2 and BARI Til-3 (The crop sown on 12 and 27 April died at about 40 and 60 days after sowing, respectively)

Table 2. Effect of sowing date and cultivar on morpho-physiological characters of sesame

Treatments	Plant height (cm)	Nodes plant^{-1} (no.)	Branches plant^{-1} (no.)	Stem wt. plant^{-1} (g)	Shell wt. plant^{-1} (g)	Stover weight (tha^{-1})	Harvest index (%)
Sowing dates:							
26 February	102.4 a	23.55 a	2.91 a	7.61 a	1.00 a	8.61 a	15.23
13 March	103.6 a	19.16 b	2.53 b	7.20 b	1.03 a	8.23 a	14.75
28 March	70.59 b	14.84 c	2.87 ab	3.11 c	0.43 b	3.54 b	13.63
Level of significance	**	**	*	**	**	**	NS
Varieties:							
Binatil-1	91.14	16.76 b	0.40 c	5.74 b	0.73 b	6.47	15.26 a
BARI Til-2	93.54	20.53 a	4.82 a	6.50 a	0.81 b	7.31	13.59 b
BARI Til-3	91.92	20.27 a	3.09 b	5.68 b	0.91 a	6.59	14.77 a
Level of significance	NS	**	**	**	**	NS	**
CV (%)	2.78	7.37	11.31	7.97	9.89	9.59	6.62

In a column figure (s) having same letter do not differ significantly at 5% level as per DMRT;
*, ** indicate significant at 5% and 1% level of probability, respectively; NS = Not significant;
†: 12 and 27 April sowing plants died at early growth stages due to heavy rainfall.

Effect of date of sowing on yield contributing characters and yield:

Significant effect of date of sowing was also found on yield and related traits of sesame cultivars (Table 3). Results revealed that total, fertile and unfertile capsule number, capsule length, number of filled and unfilled seeds capsule^{-1}, 1000-seed weight and seed yield decreased with delay sowing. The highest yield and related traits was recorded in 26 February sowing followed by 13 March sowing. In contrast, the lowest above yield attributes was recorded in 28 March sowing. Reduced number of capsules plant^{-1} under delay sowing condition might be due to production of lower number of nodes plant^{-1} (Fig. 3). Similar result was also reported by many workers (Suryavanshi *et al.*, 1990; Sukhadi and Dhoble, 1990; Suryavanshi *et al*., 1993; Tiwari *et al*., 1994; Ali *et al*., 2005). Here, early sown plants produced more seeds capsule^{-1} than the later sowing plants indicating early sowing helped plants to produce more assimilates which helped to set more fertile seed capsule^{-1}. It is possible because of early sown plant has capacity to produced more leaves than the delay sowing plants (Fig. 2). This result is consistent with the result of Ali *et al*. (2005) in sesame who reported that number of filled seeds capsule^{-1} decreased with delay in sowing.

Yield was zero in April sowing due to plant died before setting capsule for heavy rainfall. Reduced seed weight plant^{-1} as well as seed yield (kg ha^{-1}) under late sowing condition might be due to lower number of capsules plant^{-1} (Table 3). Similar result was also reported by Sarker *et al*. (2007) in sesame.

Table 3. Effect of sowing date and cultivar and their interaction on yield and related traits in sesame

Treatments	Total capsules plant^{-1} (no.)	Fertile capsules plant^{-1} (no.)	Unfertile capsules plant^{-1} (no.)	Capsule length (cm)	Filled seeds capsule^{-1} (no.)	Unfilled seeds capsule^{-1} (no.)	1000-seed weight (g)	Seed yield plant^{-1} (g)	Seed yield (kg ha^{-1})
Sowing dates:									
26 February (D_1)	64.71 a	46.00 a	18.71 a	2.75 a	52.09 a	22.72 a	2.60 a	4.46 a	1059.4 a
13 March (D_2)	56.13 b	46.07 a	10.98 b	2.82 a	50.00 a	16.24 b	2.32 b	3.70 b	986.94 c
28 March (D_3)	28.02 c	17.29 b	10.07 b	1.53 b	25.37 b	11.89 b	2.11 c	2.04 c	456.44 d
Level of significance	**	**	**	**	**	**	**	**	**
Varieties:									
Binatil-1 (V_1)	48.00 b	33.31 c	13.84 a	2.70 a	43.24 b	16.81 b	2.71 a	3.27	900.2 a
BARI Til-2 (V_2)	49.91 ab	36.44 b	13.47 a	2.54 b	49.52 a	19.49 a	2.10 b	3.53	779.1 c
BARI Til-3 (V_3)	51.04 a	40.60 a	11.44 b	1.87 c	35.70 c	14.55 c	2.21 b	3.40	823.5 c
Level of significance	*	**	**	**	**	**	**	NS	**
Sowing date × variety									
D_1 x V_1	63.60 ab	43.33 b	20.27 a	3.52 a	55.62 bc	22.43 b	2.78	4.51 a	1141.2 a
D_1 x V_2	67.00 a	46.33 a	20.67 a	2.87 b	58.83 ab	26.32 a	2.41	4.43 a	890.3 c
D_1 x V_3	63.53 ab	49.33 a	14.20 b	1.85 d	42.81 d	19.42 c	2.54	4.43 a	1146.7 a
D_2 x V_1	54.40 c	42.13 b	12.00 b	2.79 b	50.15 c	15.57 d	2.74	3.55 b	957.8 c
D_2 x V_2	59.27 bc	49.27 a	10.00 c	3.47 a	61.49 a	18.81 c	2.05	3.84 b	1062.5 b
D_2 x V_3	54.73 c	47.80 a	9.93 c	2.19 c	39.37 d	14.33 de	2.17	3.70 b	940.5 c
D_3 x V_1	25.73 e	14.47 d	9.27 c	1.75 d	23.95 e	12.43 ef	2.59	1.75 d	601.7 d
D_3 x V_2	23.47 e	13.73 d	9.73 c	1.28 e	28.25 e	13.33 de	1.83	2.31 c	384.5 e
D_3 x V_3	34.87 d	24.67 c	10.2 c	1.57 de	24.92 e	9.92 f	1.92	2.07 cd	383.2 e
Level of significance	**	**	**	**	**	*	NS	*	**
CV (%)	5.34	5.58	8.08	7.90	8.03	8.81	6.27	6.77	4.93

In a column same figure (s) do not differ significantly at $P \leq 0.05$ as per DMRT; *, ** indicate significant at 5% and 1% level of probability, respectively; NS = Not significant; †: The crop sown on 12 and 27 April died at about 40 and 60 DAS due to heavy rainfall

Effect of variety on yield contributing characters:

The effect of varieties on yield attributes and yield in sesame was significant except seed weight plant^{-1} (Table 3). The highest number of fertile capsule plant^{-1} was observed in BARI Til-3 with lowest number of seeds capsule^{-1} while the highest filled seeds capsule^{-1} was recorded in BARI Til-2. Mentionable that although Binatil-1 performed inferiority in yield attributes except seed size but showed the highest seed yield per unit area basis due to greater number of plants accommodation within a unit area for its unicum canopy stature compared to BARI Til-2 and BARI Til-3. The lowest seed yield per unit area was recorded in BARI Til-2 due to smaller size seeds.

Interaction between variety and date of sowing on yield attributes and seed yield:

Interaction of sowing dates and cultivars had significant effect on all yield attributes 1000-seed weight (Table 3). The highest seed weight plant^{-1} and seed yield hectare^{-1} was observed in Binatil-1 when sown on 26 February (4.51 g plant^{-1} and 1141 kg ha^{-1}) which was statistically similar to BARI Til-3×26 February sowing (4.43 g plant^{-1} and 1137 kgha^{-1}). In contrast, the lowest seed yield was observed in BARI Til-2 and BARI Til-3 with 28 March sowing (385 and 383 kg ha^{-1}, respectively). Results further revealed that Binatil-1 performed the best in seed yield under late sowing condition indicating Binatil-1 was more stable in producing seed yield than BARI Til-2 and BARI Til-3 under different dates of sowing from February to March.

From the results, it could be concluded that all the three cultivars performed good in early sowing i.e. last week of February or first week of March followed by a decline and yield was near to zero in April sowing. Among the studied cultivars, higher yield can be obtained by sowing of Binatil-1 and BARI Til-3 at 26 February while BARI Til-2 at 13 March.

References

Ali, A., Tanveer, A., Nadeem, M.A., Bajwa, A.L. 2005. Effect of sowing dates and row spacings on growth and yield of sesame. J. Agric. Res. 43: 19-22.

BARI. 2014. A leaflet on BARI til 2. Published by the Bangladesh Agricultural Research Institute, Gazipur-1701.

Chimanshette, T.G. and Dhoble, M.V. 1992. Effect of sowing date and plant density on seed yield of sesame varieties. Indian J. Agron. 37: 280-282.

Dhoble, M.V., Khating, E.A. and Thete, M.R. 1987. Productivity and water use efficiency of Kharif crops at varying dates of sowing. J. Maharashtra Agric. Univ. 12: 310-313.

Ghosh, D.C. and Bagdi, P.R. 1986. Yield variation on sesame sown at monthly intervals at sub-humid lateritic acid tract of West Bengal, India. Madras Agric. J. 73: 23-29.

Miah, M.A.M., Afroz, S., Rashid, M.A. and Shiblee, S.A.M. 2015. Factors affecting adoption of improved sesame technologies in some selected areas in Bangladesh: An empirical study. The Agriculturists 13(1): 140-151.

MOA. 2015. Hand Book of Agricultural Statistics, December, 2015. Market Monitoring and Information System, Ministry of Agriculture (MOA), Govt. People's Repub. Bangladesh. p. 493.

Ogundare, S.K., Ayodele, F.G. and Oloniruha, J.A. 2015. Effect of time of sowing and urea application rate on the growth and yield of two varieties of sesame in Ejiba Kogi state, Nigeria. Nigerian J. Agric. Food and Environ. 11(4):118-123.

Russell, D.F. 1986. MSTAT-C computer package programme. Crop and Soil Science Department, Michigan State University, USA.

Sarkar, M.N. Alam., Salim, M., Islam N. and Rahman, M.M. 2007. Effect of sowing date and time of harvesting on the yield and yield contributing characters of sesame (*Sesamum indicum* L.) seed. Int. J. Sustain. Crop Prod. 2(6):31-35.

Shubha, G.A.K. 2006. Effect of date of sowing and nitrogen level on the seed yield of sesame. M.S Thesis, Dept. Agron., Bangladesh Agric. Univ., Mymensingh.

Sivagamy, K. and Rammohan, J. 2013. Effect of sowing date and crop spacing on growth, yield attributes and quality of sesame. IOSR J. Agric. Vet. Sci. 5(2): 38-40.

Sukhadi, N.M. and Dhole, M.V. 1990. Studies on productivity and economics of different Kharif crops as influenced by varying dates of sowing for aberrant weather situation under dry land conditions. Indian J. Agron. 35: 227-233.

Suryavanshi, G.B., Pawar, V.S., Umarani, N.K. and Ransing, S.K. 1993. Effect of sowing date on yield and quality of sesame varieties. Indian J. Agric. Sci. 63: 496-498.

Suryavansi, G.B., Pawar, V.S. and Ransing, S.K. 1990. Effect of sowing dates on yield and yield attributes of sesame. Ann. Plant Physiol. 4: 257-259.

Tiwari, K.P., Jain, R.K. and Raghuwanshi, R.S. 1994. Effect of sowing dates and plant densities on seed yield of sesame cultivars. Crop Res. Hisar 8(2): 404-406.

Weiss, E.A. 1983. Oilseed Crops. Tropical Agric. Series, Longman, London. pp. 282-340.

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NEUTRON ENERGY RESPONSE AT DIFFERENT LAYERS OF MODERATOR AND ABSORBER

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

Abstract

A series of experiments were conducted at the research reactor of Kinki University, UTR-KINKI, Japan using various arrangements of neutron moderators and absorbers for evaluating the energy responses of wide energies neutrons at different layers and positions. Among various arrangements of moderators and absorbers, an arrangement (22mm PE+22.5mm B_4C+10mm PE+50mm PE) has been optimized, where the responses of neutron energies are found to be significant compared to all other arrangements, especially for the intermediate energy of neutrons. The experimental results are also checked and compared to the experimental result with the same arrangement using the ^{252}Cf neutron bare source at National Institute for Fusion Science (NIFS), Japan. It is assumed that the result of this study would be contributed for designing a lighter weight multi-layers moderator and absorber based cylindrical or spherical dose monitor for wide energy response of neutron.

Key words: Neutron energy, research reactor, response, moderator and absorber.

Introduction

Moderator based instruments, also known as REM-counters, are the most frequently used instruments for neutron area monitoring. The essential elements of most commercial REM counters are a neutron moderator assembly; e.g. polyethylene (PE) surrounding a thermal neutron detector; a ^{10}B enriched BF_3 or ^3He counter tube. In 1960 Bramblet, Ewing, and Bonner first introduced the system used a ^6LiI detector in a series of polyethylene moderating spheres, or Bonner spheres, ranging in size from 2 to 12 inches in diameter (Bramblett *et al*., 1960). The response of 12-inch diameter polyethylene sphere and a small ^6LiI (Eu) scintillator approximate the fluence-to-dose conversion function, and that such an instrument could be used for monitoring without regard to actual neutron spectrum. When expressed on a unit dose basis, the energy response of this instrument was shown to be fairly uniform (± 46%) from thermal to15 MeV. Hankins (Hankins *et al.*, 1962) advocated the use of a 10-inch spherical polyethylene moderator at part of a portable REM counter for measurements over the energy range from thermal to 7 MeV. He has reported a large dose overestimate for intermediate energy neutrons ranging from few hundred eV to 0.5 MeV and underestimate for energies above 7 MeV. Andersson and Braun (Andersson and Braun, 1963)

[1]Bangladesh Institute of Nuclear Agriculture, BAU Campus, Mymensingh-2202, Bangladesh
[2]On Farm Research Division, Bangladesh Agricultural Research Institute, Mymensingh-2200, Bangladesh
[3]National Institute for Fusion Science, 322-6 Oroshi-cho, Toki-shi, Gifu-ken 509-5292, Japan

designed and refined a rem meter known as AB meter based on a cylindrical polyethylene moderator and a BF_3 proportional counter tube with a goal of achieving a dose equivalent like response from thermal to 10 MeV. A novel feature of the design was the use of a neutron absorber in the form of a borated plastic sleeve around the counter tube to more accurately match the meter response per unit fluence to the shape of the fluence-to-dose conversion function at intermediate energies. Holes were drilled in the sleeve to increase the response at thermal energies. The position of the sleeve and the total area of the holes were experimentally adjusted to give a more satisfactory overall response. However, the cylindrical moderator geometry of the AB meter adversely impacts the directional response. Both Hankins and Cortez (Hankins and Cortez, 1974) and Cosack and Lesiecki (Cosack and Lesiecki, 1985) measured the change in response with instrument orientation as much as 35% for neutron energy of 1 MeV. Also, with its side oriented to a source of thermal neutrons, there was about a 65% underestimate in the true dose equivalent. Leake (Leake, 1966) introduced a spherical version of the AB meter which was commercialized as the Harwell type 95/0072. This design uses a 20.8cm diameter polyethylene moderator surrounding a ^{6}LiI (Eu) scintillator and an internal absorber of 1mm thick perforated cadmium foil. A later version of the Leake rem meter (Leake, 1968) incorporated a spherical ^{3}He proportional counter.

Motivate primarily by the need for a lighter weight monitoring instrument (relative to a 10inch sphere), and using the idea of an internal absorber introduced by the AM meter, Hankins (Hankins, 1967) designed a “modified sphere” REM counter with an energy response similar to that of a 10 inch spherical moderator. This design consists of a 22 cm diameter polyethylene external spherical shell and a 0.0028 cm thick cadmium layer positioned at a 3cm radius over an internal polyethylene sphere. The spherical symmetry of the design ensured more optimal directional response than the AB meter, but as with other pure polyethylene moderator base designs, the high-energy response decreases steadily above 7 MeV. At the work places of neutron generating facilities like the fusion reactors, fission research reactors and nuclear power plants etc. neutrons are always present with wide energies ranges from thermal to tens of MeV (ICRP, 1990). But the dose response of almost all REM counters typically includes an error, especially in the intermediate energy range around 0.1 keV–100 keV (Alberts*et al.*, 1996; Bartlett *et al.*, 1997; Burgkhardt *et al.*, 1997). The intermediate energy of the neutrons contributes significantly to the ambient dose equivalent at workplaces (Klett and Burgkhardt, 1997). Since, at the work place of the nuclear power plant neutrons are present with wide energies ranges from thermal to tens of MeV (Mill, 1982), therefore each energy group of neutrons have to be considered during dose evaluation. For this reason response of wide neutron energies is important factor for evaluating the dose by the detectors of neutron dose monitor.

The Kinki University Reactor**,** UTR-KINKI is a light water-moderated and graphite-reflected reactor. The nominal power is 1 watt. The neutron energy spectrum in the core seems to be close to 1/E standard field in the energy region from a few eV to a few hundred keV because graphite is used as reflector. The neutron fields have been characterized for radiation protection and other applications at the KINKI university reactor. A series of experiments were conducted at UTR-KINKI using various arrangements of neutron moderators and absorbers for evaluating the energy responses of wide energies neutrons at different layers and positions. During the experiments the instrument was placed at the top of the reactor where neutron comes through a hole of reactor about 50 mm of diameter. The experimental results were also compared with the experimental results of NIFS using the ^{252}Cf bare source. The objective of this study is to know the neutron energy responses at different layers of the moderators and absorber, especially for the intermediate energy of neutron at boron carbide (B_4C) layer.

Materials and Methods

The irradiation experiments were conducted at UTR-KINKI using different arrangements of moderators and absorber as shown in Fig. 1 and Fig. 2. The thickness of moderators and absorbers were chosen from the simulated results of Monte Carlo N-Particle Transport Code (MCNP). Two types of TLD, one is $CaSO_4(Tm)+^6LiF$ with commercial name UD136 detects the thermal neutron and photon simultaneously and another is $CaSO_4(Tm)$ named UD110 that detects photon only, have been used for the measurements. TLDs UD136 and UD110 were annealed at 400°C for 6 and 4 minutes, respectively. Three sets of TLD (UD136+UD110) were placed in different positions (POS-1, POS-2, POS-3 and POS-4) at bottom of the middle portions of the moderators and absorbers as in Fig. 1 and Fig. 2 for the irradiation. The instrument was placed at the top of the reactor from where neutron comes through a hole about 50mm of diameter. Using 1watt reactor power, the exposure time were 90 and 120 minutes for two experiments of Fig. 1 and Fig. 2, respectively.

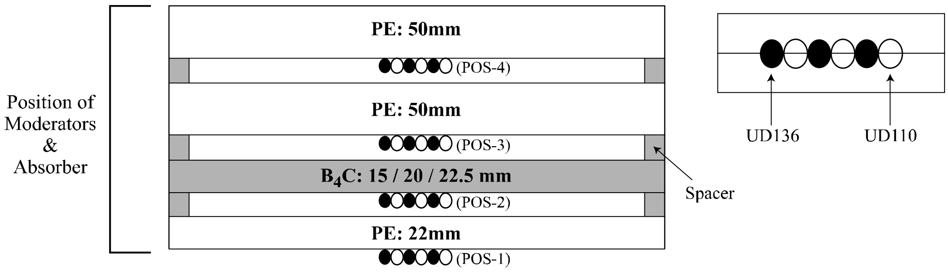

Fig. 1. Arrangement of experiment at research reactor of UTR-KINKI (without 10mm PE)

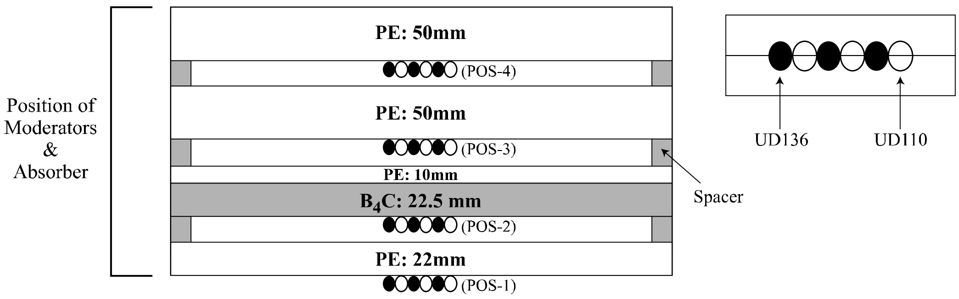

Fig. 2. Arrangement of experiment at research reactor of UTR-KINKI (with 10mm PE)

At POS-1, TLD were irradiated directly and reaction occurred only with thermal neutrons coming from 50mm hole of the reactor. At POS-2, reaction occurred after moderation of slow neutrons into thermal neutrons with interaction to 22mm polyethylene (PE). At POS-3, 15mm, 20mm and 22.5mm B_4C were used for three different experiments as shown in Fig. 1. In case of Fig. 2 arrangement, 22.5mm B_4C plus 10mm PE was used instead of B_4C, where B_4C acts as an absorber of thermal neutrons causing high cross section of boron and 10mm PE acts as neutron reflector. Finally, at POS-4, fast neutrons were moderated by 50mm PE then reaction occurred with moderated thermal neutrons. The additional 50mm PE acts as a neutrons reflector. TLD (10 Nos. each) have been used as control. Control reading was subtracted from the measured value for each type of TLD. The net neutron energy response was found using [R(UD136)-R(UD110)], which is to be considered as readout data. TLD readings were measured by using UD-512, Panasonic TLD reader.

Results and Discussions

Experiments at UTR-KINKI without 10mm PE

In all experimental measurements, first set of TLDs i.e. at POS-1 has responded by thermal neutrons directly came out from the reactor those were detected by TLDs via the reaction of ^{6}Li (n, α) T. Slow, intermediate and fast neutrons were moderated by 22mm thickness of PE. After moderation some neutrons became thermal and then detected at POS-2. At POS-3, moderated thermal neutrons were assumed to be absorbed by B_4C causing high cross section of boron. At POS-4, the resultant neutron spectrum is moderated by the first 50mm of PE and some neutrons were reflected from the other additional 50mm of PE and then moderated thermal neutrons were detected by TLDs.

Table1. Readout data of different arrangements of moderator and absorber (in mR)

Expt. No.	Arrangements	POS-1	POS-2	POS-3	POS-4
1 (KINKI)	22+15+50+50	1150 ± 57	147 ± 10	2.9 ± 4.7	27 ± 1
2 (KINKI)	22+20+50+50	1134 ± 24	160 ± 11	-1.1 ± 4.4	19 ±5
3 (KINKI)	22+22.5+50+50	1193 ± 42	180 ± 45	1.9 ± 0.6	21± 3
4 (KINKI)	22+22.5+10+50+50	1300 ± 20	213± 61	15.0 ± 3.0	21 ± 3.8
5 (KINKI)	22+22.5+10+50+50	1204 ± 49	201± 14.3	14.3 ± 4.5	25 ± 6
6 (NIFS)	22+22.5+10+50+50	0.1 ± 1.8	3.0± 1.1	4.7 ± 0.7	7.4 ± 0.3

In Table1 of experiments No. 1, 2 and 3 of KINKI are indicating the net readout data i.e. [(R(UD136)-R(UD110)] of different arrangements and positions of TLDs for measurements 1, 2 and 3, respectively of UTR-KINKI. The thicknesses of B_4C for three measurements were considered 15, 20 and 22.5 mm to know the different responses of intermediate energy of neutrons. The responses were not found significantly at intermediate energy region of neutrons for all three measurements. The amount of response at the second depths of detector of POS-3 was found too small because of direct absorption of thermal neutrons near the second layer detectors. So, it was assumed that further experiment has to be needed using 10mm PE along with B_4C.

Experiments at UTR-KINKI with 10mm PE

Since the energy responses of intermediate energy of neutrons after B_4C region were not found significant values for the previous experiment of three measurements, therefore, the response of the POS-3 was needed to improve for getting a significant value. In order to improve the response at second depths detectors of POS-3, the experiment was performed with addition of 10mm thickness PE layer after 22.5mm B_4C layer. It is assumed that the 10mm PE plays a role as a reflector of neutrons and it was also expected that PE may prevent direct absorption of thermal neutrons to B_4C near the second layer TLDs. In order to check the expectation, two measurements 4 and 5 have been performed. The total response at POS-3 was found to be more than 6 times higher than that of without 10mm PE. In Table1 of experiments No. 4 and 5 of KINKI are indicating the net readout response data i.e. [(R(UD136)-R(UD110)] of different arrangements and positions of TLDs for measurements 4 and 5, respectively of UTR-KINKI.

Experiment at NIFS with 10mm PE

Experiment No. 6 was performed at NIFS using the ^{252}Cf bare source of 0.11 MBq at a distance of 6 cm from the instrument for 48 hours irradiation. Table 1 shows the readout data for the arrangement of 22.5mm B_4C plus with 10mm of PE. In order to discuss the sensitivity for different energy distribution among measurements 4, 5 and 6, the readout data was normalized by the readout data of POS-4 as a standard. The normalized average values of measurements 4 & 5 found to be 55.0, 9.0, 0.63 for POS-1, POS-2 and POS-3, respectively, while in case of measurement 6 these are found to be 0.01, 0.41, 0.64. The values are large at POS-1 and POS-2 for measurements 4 & 5, because large amount of thermal and low energy neutrons were came out from reactor and detected compare to measurement 6 of fast neutron^{252}Cf source. At POS-3, the normalized value is found to be similar for both UTR-KINKI and NIFS experiments, which indicates that there is no large difference for the ratio of intermediate energy and fast neutrons. Finally, the arrangement of (22mm PE+22.5mm B4C+10mm PE +50mm PE) has been optimized for the significant responses of wide energies of neutrons i.e. thermal, slow, intermediate and fast neutrons which will help for designing the three dimensional thin layered moderators and absorbers based neutron dose monitor either cylindrical or spherical.

Conclusions

Neutron moderator and absorber based REM-counters are the most frequently used for neutron area monitoring, but their dose response typically includes an error, especially in the intermediate energy range around 0.1 keV–100 keV. Since, at the work places of neutron producing fields neutrons are always present with wide energies ranges i.e. thermal, slow, intermediate and fast neutrons, so each energy groups of neutrons must be considered during dose evaluation. Therefore, considering each energy groups of neutrons, experiments were conducted at UTR-KINKI in order to know the neutron energy responses at different layers and positions of the moderators and absorbers. Among various arrangements of moderators and absorbers the responses of neutrons energies of all groups are found to be significant, especially for the intermediate energy of neutrons for an optimized arrangement. An experiment was also conducted using ^{252}Cf neutron bare source at NIFS to compare the experimental results with the same arrangements of UTR-KINKI. It is expected that the information gathered from this study will contribute to design a lighter weight multi-layers moderators and absorbers based neutron dose monitor for evaluating the precise dose of wide energies of neutrons.

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References

Alberts, W.G., Bordy, J.M., Chartier, J.L., Jahr, R., Klein, H., Luszik-Bhadra, M., Posny, F., Schuhmacher, H. and Siebert, B.R.L. 1996. Neutron Dosimetry, Radioprotection. 31:37-65.

Andersson, I.O. and Braun, J.A. 1963. Neutron dosimetry, Proceedings of anInternational Atomic Agency symposium, Vienna, IAEA STI/PUB/69. II: 87-95.

Bartlett, D.T., Tanner, R.J. and Jones, D.G. 1997. A New Design of Neutron Dose-equivalent Survey Instrument. Radiation Protection Dosimetry. 74: 267-271.

Bramblett, R.L., Ewing R.I. and Bonner, T.W. 1960. A new type of neutron spectrometer, Nucl. Instrum. Meth. 9:112-124.

Burgkhardt, B., Fieg, G., Klett, A., Plewnia, A. and Siebert, B.R.L. 1997. The Neutron Fluence and *H*(10)* Response of the New LB6411 Rem Counter, Radiation Protect. Dosimet. 70: 361-364.

Cosack, M. and Lesiecki, H. 1985. Dose equivalent survey meters, Radiat. Prot. Dosim. 10: 111-119.

Hankins, D.E. 1962. A modified-sphere neutron detector, Los Alamos ScientificLaboratory, Report. LA-2717.

Hankins, D.E. 1967. Los Alamos Scientific Laboratory, Report. LA-3595.

Hankins, D.E. and Cortez, J.R. 1974. Los Alamos Scientific Laboratory, Report LA-5528.

ICRP. Oxford: Pergamon press, 1990. Recommendation of the International Commissionon Radiological Protection, Publication 60, Annex A.

Klett, A. and Burgkhardt, B. 1997. The New Remcounter 6411: Measurement of Neutron Ambient Dose Equivalent *H*(10)* according to ICRP60 with High Sensitivity. IEEE, Transac. Nucl. Sci. 44: 757-759.

Leake J.W. 1966. A spherical dose equivalent neutron detector. Nucl. Instrum. Methods. 45:151-156.

Leake, J.W. 1968. An Improved Spherical Dose Equivalent Neutron Detector. Nucl. Instr. Meth. 63: 329-332.

Mill, A.J. 1982. The radiological importance of neutrons within the nuclear powerindustry, J. Soc. Radiol. Protec. 2: 15-19.

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MICRONUTRIENT RECOMMENDATION FOR THE POTATO-*BORO*-T. *AMAN* CROPPING PATTERN UNDER TISTA MEANDER FLOODPLAIN SOIL AT RANGPUR

M. F. Islam[1], M. R. Islam[2], A. Parvin[3]

Abstract

Crop experiments were accomplished in two ways over two years. These experiments were conducted at BINA sub-station and a farmer's field of Rangpur district. In year-one the field trials were done at BINA substation and a farmer's plot taking six micronutrients (B, Zn, Cu, Mn, Fe & Mo) and the treatments were designed in an additive manner. These elements were imposed to the first crop and their residual effects were monitored on the next two crops in a year or cropping pattern. The cropping pattern was potato-*boro*-T. *Aman* rice. The rates of micronutrient application were 3 kg Zn, 2 kg B, 2 kg Cu, 3 kg Mn, 5 kg Fe and 1 kg Mo per hectare. They were added as fertilizers such as $ZnSO_4.7H_2O$, H_3BO_3, $CuSO_4.5H_2O$, $MnCl_2$, $FeSO_4.7H_2O$ and Na_2MoO_4, respectively. Other nutrients viz. N, P, K & S were applied at recommended rates to all plots; rationale was followed for the second and third crops across the year. Based on the results of the year-one crop experiment, the year-two experiment was designed with two selected micronutrients Zn and B at Kaunia upazila under Rangpur district. The rates of Zn application were 0, 2, 4 & 6 kg ha^{-1}, and the rates for B were 0, 1.5 and 3 kg ha^{-1}. Addition of these two micronutrients was designed in such a way that it would be clear whether one-crop, two-crop or three-crop application is necessary to achieve satisfactory crop growth as well as yield. The same cropping pattern was tested. The $Zn_2B_{1.5}$-Zn_0B_0-Zn_0B_0 treatments combination showed the highest MBCR (16.2) followed by the $Zn_4B_{1.5}$-Zn_0B_0-Zn_0B_0 and $Zn_2B_{1.5}$-Zn_0B_0-Zn_2B_0 combinations (both 13.3) and the $Zn_4B_{1.5}$-Zn_0B_0-Zn_2B_0 combination (10.2). It could be suggested that Zn application at 4 kg ha^{-1} coupled with B application at 1.5 kg ha^{-1} to the first crop could meet their requirement for the subsequent two crops in a pattern. For the two rice crops in a pattern, B application at 1.5 kg ha^{-1} to the first crop and split application of Zn at 2 kg ha^{-1} to the first and third crops can give better yield benefit.

Key words: Micronutrient, cropping pattern, tista meander floodplain soil, yield

Introduction

Rice and rice based cropping system have an important role in Bangladesh to increase food production for a rapidly growing population. Zinc deficiency is the most widespread micronutrient disorder in lowland rice and application of Zn along with NPK fertilizer

[1]Bangladesh Institute of Nuclear Agriculture, BAU Campus, Mymensingh-2202, Bangladesh
[2]Department of Soil Science, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh
[3]Ex. Deputy Manager (Agriculture), Bangladesh Institute of ICT in Development.

increases the grain yield dramatically in most cases (Fageria *et al*., 2011). In general, soil application of 5 kg Zn ha^{-1} is recommended for rice in India (Gupta *et al*., 2007). The fertility status of soils is variable and in most of the areas it has declined. Cultivation of high yielding varieties for all crops has increased remarkably. Consequently, this has resulted in deterioration of soil fertility with emergence of micronutrient deficiency. In Bangladesh chronologically N, P, K, S, Zn and B deficiencies have appeared in soils and crops. Among the micronutrients, next to zinc, boron deficiency is prominent in soils of Dinajpur, Rangpur, Bogra, Sirajganj, Mymensingh, Comilla and Sylhet district (SRDI, 2010). Boron deficiency of some crops was reported (Jahiruddin *et al*., 1995) in early 1990's. There is sporadic information of Cu, Mo and Mn deficiencies in crops (Bhuiyan *et al*., 1998). Micronutrients that are essential for crops include Fe, Mn, Zn, Cu, Mo, Cl and B. Micronutrient trials have been made principally on rice (Jahiruddin *et al*., 1994), wheat (Hossain, 2005) and maize (Hossain *et al*., 2008). However, cropping pattern based micronutrient research is limited. Zinc deficiency is particularly evident in calcareous and wetland rice soils (SRDI, 2008). Zinc deficiency in crops reduces not only the crop yield, but also hampers nutritional quality (Cakmak, 2008). Although taken up in small quantities, boron deficiency may lead to serious consequences regarding economic yield of various crops. Light textured soils of the country are deficient in plant available boron where significant leaching loss of borate ions occurs. Gupta (1979) states that because of non-ionic nature, boron is once released from soils it can be leached out from soils fairly rapidly. In Bangladesh, boron deficiency is more common in *rabi* crops (dry season), as observed in wheat (Jahiruddin, 2011), mustard (Hossain, 2007), chickpea (Johnson *et al.*, 2005) and lentil (Srivastava*et al.*, 2000). Rashid *et al*. (2009) have shown 15-25% increase in grain yield of rice over N, P and Zn coupled with appreciable improvement in grain and cooking quality with application of B. Research is needed to determine all the deficient elements, whether macronutrients or micronutrients. Fertilizer management is needed on sustainable basis. Fertility management systems that profitable for short-term and sustainable for long-term should be formulated and it needs to be confirmed by on-farm research trials. Keeping the above points in view, the present study was carried out to evaluate the effect of micronutrients application on the yield of potato, *boro* and T. *Aman* rice crops and to find out the optimum rate of micronutrients for the potato-*boro*-T. *Aman* cropping pattern in AEZ 3.

Materials and Methods

For experiment 1, the treatments were designed taking all micronutrients except Cl following additive element trial technique. The experiments were laid out in a Randomized Complete Block Design (RCBD), with three replications. There were seven treatments with six micronutrients, as follows:T_1:Control (No use of micronutrients), T_2:Zn, T_3:Zn+B, T_4:Zn+B+Cu, T_5: Zn+B+Cu+Mn, T_6: Zn+B+Cu+Mn+Fe, T_7:Zn+B+Cu+Mn+Fe+MoThese micronutrient treatments were imposed on the first crop only (Expt. I) and their residual effects were observed on the next two crops over the year. The rates of micronutrients were 3kg Zn, 2kg B, 2kg Cu, 3kg Mn, 5kg Fe and 1kg Mo per hectare. The elements were added as $ZnSO_4.7H_2O$ (23% Zn), H_3BO_3 (17% B), $CuSO_4.5H_2O$ (25% Cu), $MnCl_2$ (17% Mn), $FeSO_4.7H_2O$ (19% Fe) and Na_2MoO_4 (39% Mo), respectively. Other nutrients viz. N, P, K & S were used at recommended rates for all plots (for potato 120-25-100-10, boro 120-15-45-10 and T. *Aman* 90-15-40-10 kg ha^{-1}N-P-K-S, respectively from urea, TSP, MoP and gypsum); rationale was followed for the second and third crop within a year. For the potato, one-third urea was applied at final land preparation. The first earthing-up was done after the second dose of urea application at 30 DAP (days after planting). The 2^{nd}earthing-up was done at 40 DAP. Irrigation was provided once at 35 DAP. To control late blight disease, Ridomyl was sprayed at 10 day intervals starting from 15 DAP until maturity. Potato was harvested 85 days after planting in two locations. For the rice, the one-third urea was applied after seven days of transplanting and the rest at an equal rate during the maximum tillering and panicle initiation stages. The experiment 1 was conducted at BINA substation farm and in a farmer's field both at Rangpur. Potato tubers (cv. Diamant) were planted on 17 and 18 November of 2011 at BINA sub-station and farmer's fields, respectively, at the rate of 2000 kg ha^{-1} with 60 cm × 30 cm spacing. *Boro* rice (cv. BRRI dhan29) seedlings (45 days old) were transplanted on 02 and 03 February of 2012 at farmer's field and BINA sub-station, respectively, with spacing of 15 cm × 20 cm. T. *Aman* (cv. Binadhan-7) rice seedlings (27 days old) were transplanted on 23 and 24 July 2012 at BINA sub-station and farmer's field, respectively, with 15cm × 20cm spacing @ 2 seedlings $hill^{-1}$.

Based on the results of experiment 1, Zn and B treatments were designed for next year Experiment 2 to ascertain whether 1st-crop, 2nd-crop and 3rd-crop application is required in one year- crop cycle in terms of crop growth, yield and cost. It was conducted at Kaunia, Rangpur in a farmer's plot by potato seed sowing on 18 November 2012 and completed by T. *Aman* rice harvest. Crop variety, seed rate, seedling age, spacing etc. were maintained as experiment 1. Before conducting field experiments soil samples were collected and analyzed. The soil properties are presented in Table 1. Data on the yield and yield contributing characters of the crops were recorded and analyzed statistically following Duncan's New Multiple Range Test (DMRT). The treatments of experiment 2 were as follows:

Wheat		**Mungbean**		**T. *Aman***	
Treatment code	Treatment combination	Treatment code	Treatment combination	Treatment code	Treatment combination
T_1	Zn_0B_0	$T_{1.1}$	Zn_0B_0	$T_{1.1.1}$	Zn_0B_0
		$T_{2.1}$	Zn_0B_0	$T_{2.1.1}$	Zn_0B_0
				$T_{2.1.2}$	Zn_2B_0
T_2	$Zn_2B_{1.5}$	$T_{2.2}$	Zn_2B_0	$T_{2.2.1}$	Zn_0B_0
				$T_{2.2.2}$	Zn_2B_0
		$T_{2.3}$	$Zn_2B_{1.5}$	$T_{2.3.1}$	Zn_0B_0
				$T_{2.3.2}$	Zn_2B_0
T_3	$Zn_4B_{1.5}$	$T_{3.1}$	Zn_0B_0	$T_{3.1.1}$	Zn_0B_0
				$T_{3.1.2}$	Zn_2B_0
T_4	Zn_6B_3	$T_{4.1}$	Zn_0B_0	$T_{4.1.1}$	Zn_0B_0

Subscripts of Zn and B represent kg ha^{-1}.

Table 1. Soil morphological, physical and chemical properties of the experimental sites (Experiment I & II)

Soil properties	BINA sub-station	Farmer's field	Farmer's field at Kaunia
	Experiment I		Experiment II
A. Morphological properties			
AEZ (UNDP and FAO, 1988)	Tista Meander Floodplain	Tista Meander Floodplain	Tista Meander Floodplain
General soil type	Non-calcareous Brown Floodplain soil	Non-calcareous Brown Floodplain soil	Non-calcareous Brown Floodplain soil
Soil series	Gangachhara	Gangachhara	Kaunia
Topography	Medium high land	Medium high land	Medium high land
Drainage	Well drained	Well drained	Well drained
Flood level	Above flood level	Above flood level	Above flood level
B. Physical properties			
Sand (%) (2-0.05 mm)	57.9	55.4	49.5
Silt (%) (0.05-0.002mm)	21.3	27.5	35.3
Clay (%) (<0.002 mm)	20.8	17.1	15.2
Soil texture	Sandy loam	Sandy loam	Sandy loam
C. Chemical properties			
pH	5.28	5.63	6.10
OM (%)	0.83	0.83	1.77
Total N (%)	0.04	0.045	0.091
Ex. K (cmol kg^{-1})	0.13	0.07	0.07
P (µg g^{-1})	30.40	14.6	7.92
S (µg g^{-1})	23.05	35.5	4.20
Zn (µg g^{-1})	0.80	0.66	0.78
B (µg g^{-1})	0.17	0.18	0.25
Cu (µg g^{-1})	2.47	2.33	-
Mn (µg g^{-1})	27.10	18.2	-
Fe (µg g^{-1})	47.60	54.7	-

Economic analysis was done following the principle of partial budget analysis (Kay, 1981). Marginal benefit-cost ratio (MBCR), the ratio of marginal or added benefits and costs, is the indicative of the superior treatments. Only variable costs i.e. chemical fertilizer was taken into account as added cost for each cropping system. The benefit was calculated based on yield (main product and by-product).

To compare different treatments with control treatment the following equation was used.

$$\text{MBCR (over control)} = \frac{\text{Gross return}\,(T_i) - \text{Gross return}\,(T_1)}{\text{VC}\,(T_i) - \text{VC}\,(T_1)}$$

$$= \frac{\text{Added beneft (over control)}}{\text{Added cost (over control)}}$$

Where, T_i = various treatments
T_1 = control treatment
VC = Variable cost (Zn & B fertilizers costs)
Gross return = Yield × Price

The collected data were analyzed statistically following the analysis of variance (ANOVA) technique and the mean differences were adjudged by Duncan's Multiple Range Test (DMRT) using the statistical computer package program, MSTAT-C.

Results and Discussion

Results from experiment 1 (Table 2) revealed that the effect of Zn and B addition was distinct in all crops (except *boro* in farmer's field) across the location. With this end in view, Zn and B treatments were designed for next year (2012-13) experiment 2 of the same potato-*boro*-T. *Aman* crop sequence.

Table 2. Effects of micronutrients on the crops in potato-*boro*-T. *Aman* crop sequence

Treatments	Potato				Boro				T. *Aman*			
	BINA Sub-station farm		Farmer's field		BINA Sub-station farm		Farmer's field		BINA Sub-station farm		Farmer's field	
	Tuber yield (t/ha)	Haulm yield (t/ha)	Tuber yield (t/ha)	Haulm yield (t/ha)	Grain yield (t/ha)	Straw yield (t/ha)	Grain yield (t/ha)	Straw yield (t/ha)	Grain yield (t/ha)	Straw yield (t/ha)	Grain yield (t/ha)	Straw yield (t/ha)
T_1	19.41b	0.88c	14.94e	0.68g	4.06b	4.53c	3.77c	3.98c	4.06d	4.45c	3.48b	4.08b
T_2	22.21a	1.01ab	17.55d	0.79f	4.92a	5.22b	4.43b	4.67ab	4.66ab	5.04b	5.34a	6.25a
T_3	23.21a	1.06ab	22.22a	1.01a	4.96a	5.31b	4.27bc	4.78ab	4.95a	5.22ab	5.34a	6.25a
T_4	23.28a	1.06ab	20.83b	0.94b	5.08a	5.54ab	4.91a	5.10a	4.53abc	5.65a	4.40ab	5.15ab
T_5	24.08a	1.10a	18.38cd	0.83e	5.14a	5.75a	4.27bc	4.55ab	4.33bcd	5.39ab	3.95b	4.62b
T_6	22.08a	1.00b	18.94c	0.86c	4.91a	5.32b	4.25bc	4.58ab	4.18cd	4.91bc	4.40ab	5.15ab
T_7	23.88a	1.08ab	18.75c	0.85d	5.05a	5.60ab	4.07bc	4.40bc	4.26bcd	5.16ab	4.65ab	5.44ab
CV (%)	4.96	4.65	2.71	3.49	5.28	4.06	6.03	6.92	5.10	5.92	14.67	9.57

Means followed by same letter in a column are not significantly different at 5 % level by DMRT.

Tuber yield of potato: The effect of Zn-B application on tuber yield of potato was found positive and significant (Table 3). The tuber yield ranged from 24.2-28.3 t ha^{-1} over the Zn-B treatments. An increased tuber yield of 7-14% was observed in Zn-B treatments. The T_3 treatment (Zn at 4 kg ha^{-1} and B at 1.5 kg ha^{-1}) gave the maximum tuber yield which was followed by T_4 (Zn at 6 kg ha^{-1} and B at 3 kg ha^{-1}, 27.0 t ha^{-1}) and T_2 (Zn at 2 kg ha^{-1} and B at 1.5 kg ha^{-1}, 26.0 t ha^{-1}) treatments. In contrast, the minimum tuber yield was obtained from T_1 (control) treatment that received only NPKS. This result agreed well with the soil test value of Zn (0.78 μg g^{-1}) and B (0.25 μg g^{-1}) which showed a deficient level. About 14% yield benefits was observed in T_3 ($Zn_4B_{1.5}$) treatment compared to micronutrient control. Imbalanced use of fertilizers is one of the main reasons for low yield of potato. Balanced use of micro and macronutrients can considerably increase the yield (Nazli, 2010).

Table 3. Effects of micronutrients on the grain and straw/haulm yields of crops in the potato-*boro*-T. *Aman* rice cropping pattern and partial economic analysis for different treatments

Potato	Boro	T. *Aman*	Potato		Boro		T. *Aman*		Added cost (Tk/ha)	Gross return (Tk/ha)	Added benefit over control (Tk/ha)	MBCR (over control)
Treatment code			Tuber yield (t/ha)	Haulm yield (t/ha)	Grain yield (t/ha)	Straw yield (t/ha)	Grain yield (t/ha)	Straw yield (t/ha)				
T_1	$T_{1.1}$	$T_{1.1.1}$	24.2b	1.11b	4.86c	5.18d	3.58e	4.12d	-	305710	0	0.0
T_2	$T_{2.1}$	$T_{2.1.1}$	26.0ab	1.14b	6.20a	7.12ab	4.33ab	5.36ab	2895	353140	46880	16.2
		$T_{2.1.2}$					4.77a	4.90bc	4026	359850	53590	13.3
	$T_{2.2}$	$T_{2.2.1}$			5.66ab	7.34ab	3.77de	4.61cd	4026	336680	30420	7.6
		$T_{2.2.2}$					4.37ab	4.96abc	5156	346030	39770	7.7
	$T_{2.3}$	$T_{2.3.1}$			5.45bc	6.58bc	3.72de	5.01abc	5790	332420	26160	4.5
		$T_{2.3.2}$					4.23bc	5.06abc	6921	340120	33860	4.9
T_3	$T_{3.1}$	$T_{3.1.1}$	28.3a	1.29a	5.87ab	6.13c	4.07bcd	5.48a	4026	359820	53560	13.2
		$T_{3.1.2}$					4.05bcd	4.67cd	5156	358710	52450	10.2
T_4	$T_{4.1}$	$T_{4.1.1}$	27.0ab	1.26a	6.06ab	7.56a	3.86cde	4.76bc	6921	351590	45330	6.5
CV %			1.16	2.25	6.06	6.98	6.31	6.60				

Means followed by same letter in a column are not significantly different at 5 % level by DMRT; **Price (Rate/kg):** Zinc sulphateheptahydrate Tk. 130; Boric acid Tk. 200; Potato tuber Tk. 7.00, haulm 0.50; Rice grain 15, straw 1.00

Taheri (2011) obtained the maximum dry matter of potato tuber by using 50 kg ha^{-1} $ZnSO_4$. Segura *et al.* (2007) recorded significant effect of B applications at 1 kg B ha^{-1} plus 18 kg Ca ha^{-1} on the yield and tuber quality of potato. Lora *et al.* (2002) found significant effect of B level and B source on potato at 0.5 kg B ha^{-1} from Borato15. Khalil *et al.* (2002) from a field experiment on alluvial clay-loam soils for two seasons reported that tuber yield was linearly increased at 3 kg B ha^{-1} treatment. Boron application enhanced the dry matter content and starch content of potato.

Haulm yield of potato: The Zn-B treatments had significant effect on haulm yield of potato (Table 2). The haulm yield (sun dry basis) due to different treatments varied from 1.11 t ha^{-1} to 1.29 t ha^{-1}, the highest haulm yield being 1.29 t ha^{-1} recorded in treatment T_3 (Zn at 4 kg ha^{-1} and B at 1.5 kg ha^{-1}) followed by treatment T_4 (Zn at 6 kg ha^{-1}and B at 3 kg ha^{-1}, 1.26 t ha^{-1}) and T_2 (Zn at 2 kg ha^{-1} and B at 1.5 kg ha^{-1}, 1.14 t ha^{-1}) treatments. Treatments T_3 ($Zn_4B_{1.5}$) and T_4 (Zn_6B_3) were statistically identical in respect of haulm yield of potato. The lowest haulm yield (1.11 t ha^{-1}) was noted in T_1 (control) treatment receiving no micronutrient.

Grain yield of *boro* rice: The Zn-B application exerted significant and positive effect on the grain yield of *boro* rice. The grain yield ranged from 4.86-6.20 t ha^{-1} (Table 3). Treatment comprising residual effect of Zn-B along with NPKS gave the maximum grain yield (yield increment by 10.8-21.6% over control). The maximum grain yield (6.20 t ha^{-1}) was observed in $T_{2.1}$ treatment (Zn at 2 kg ha^{-1} and B at 1.5 kg ha^{-1} applied to the 1st crop, potato) treatment indicating that when the first crop (potato) received Zn at 2 kg ha^{-1} and B at 1.5 kg ha^{-1} there was no need to supply further Zn or Zn+B to the second crop (*boro* rice). Treatment $T_{2.2}$ (Zn 2 kg ha^{-1} and B 1.5 kg ha^{-1} to potato and only Zn to boro rice at 2 kg ha^{-1}, 5.66 t ha^{-1}), $T_{3.1}$ (Zn 4 kg ha^{-1} and B at 1.5 kg ha^{-1} to the 1st crop, potato, 5.87 t ha^{-1}) and $T_{4.1}$ (Zn 6 kg ha^{-1} and B 3 kg ha^{-1} to the 1st crop, potato, 6.06 t ha^{-1}) were found statistically identical yield. Further Zn-B addition at $T_{2.3}$ (Zn at 2 kg ha^{-1} and B at 1.5 kg ha^{-1} to the *boro* rice crop) did not show further increase in grain yield. The significant influence of the treatments established a residual effect of the micronutrients on the following crop.

Metwally *et al*. (2012) stated that micronutrient fertilizer application for every crop might not be necessary since its residual influence might be sufficient for achieving sustainable yield over a cropping pattern. Maharana *et al.* (1993) observed a significant response of rice yield to $ZnSO_4$ application in both *kharif* and *rabi* seasons. Hussain and Yasin (2004) quantified rice yield increase by 16% over control with the application of 1 kg B ha^{-1} whereas Rashid *et al*. (2002) reported an increase of 5-26% in rice yield with B application. Rashid *et al*. (2009) reported a 15%-25% increase in seed yield over N, P and Zn, coupled with appreciable improvement in grain/cooking quality with application of B in Pakistan. Saleem *et al.* (2011) in Malaysia have noted that one application of B significantly increased all plant growth parameters and yield of rice for two seasons. Jahiruddin *et al.* (1994) observed a 28% yield increase for *boro* rice at BAU farm, Mymensingh after combined application of S, Zn and B. Zaman *et al*. (1994) also found a positive effect on Zn fertilization on the grain yield of rice at the BAU farm.

Straw yield of *boro* rice: The straw yield of *boro* rice was significantly influenced by the residual effects of Zn-B treatments ranging from 5.18-**7**.57 t ha^{-1} (Table 3). The $T_{4.1}$ (Zn at 6 kg ha^{-1} and B at 3 kg ha^{-1} to potato) treatment gave the 31.48 % higher straw yield over control ($T_{1.1}$) followed by treatment $T_{2.2}$ (Zn 2 kg ha^{-1} and B at 1.5 kg ha^{-1} to the first crop and again 2 kg ha^{-1} Zn to the second crop, *boro* rice, 7.34 t ha^{-1}), $T_{2.1}$ (Zn at 2 kg ha^{-1} and B at 1.5 kg ha^{-1} to the first crop, 7.12 t ha^{-1}), $T_{2.3}$ (Zn 2 kg ha^{-1} and B at 1.5 kg ha^{-1} to potato and *boro* rice, 6.58 t ha^{-1}) and $T_{3.1}$ (Zn 4 kg ha^{-1} and B at 1.5 kg ha^{-1} to the first crop, potato, 6.13 t ha^{-1}). The Zn-B treatments had residual effect on the second crop (*boro* rice) indicating that when the first crop (potato) receive Zn-B, there is no need to supply further Zn or Zn-B to the *boro* rice. Application of recommended rates of macronutrients with no micronutrient addition ($T_{1.1,}$ control) showed the minimum straw yield (5.18 t ha^{-1}).

Grain yield of T. *Aman* rice: Significant residual effect of Zn-B treatments on the grain yield of T. *Aman*, the third crop in one-year crop cycle, was observed (Table 3). Treatments ($T_{2.1.1}$-$T_{4.1.1}$) comprising residual effect of Zn-B gave the maximum grain yield showing a 3.76-24.94% yield increase over Zn-B control ($T_{1.1.1}$). The grain yield varied from 3.58 to 4.77 t ha^{-1} across the treatments. The maximum grain yield was observed (4.77 t ha^{-1}) in $T_{2.1.2}$ treatment (Zn at 2 kg ha^{-1} and B at 1.5 kg ha^{-1} to the first crop, again Zn at 2 kg ha^{-1} to T. *Aman* rice, the thrid crop). Observing the effects of Zn-B treatments on the third crop (T. *Aman* rice) it appeared that the Zn application at 2 kg ha^{-1} plus B addition at 1.5 kg ha^{-1} to the first crop (potato), with no application of these two elements (Zn-B) to the second crop (*boro* rice) and application of only Zn at 2 kg ha^{-1} to the third crop showed superior yield performances of rice. The control treatment having no Zn-B had the lowest yield (3.58 t ha^{-1}). The grain yield of T. *Aman* rice increased by 3.9-33.2% over absolute control (3 crops) against 7.6-40.5% yield increase for the wheat based pattern (Fig. 1. Percent grain yield increase of T. *Aman* rice due to Zn and B application over control).

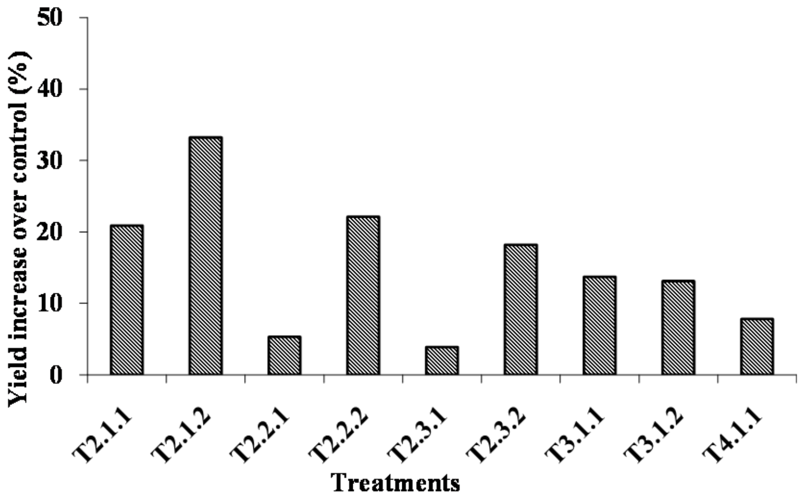

Fig. 1. Percent (%) grain yield increase of T. *Aman* rice due to Zn and B application over control

Straw yield of T. *Aman* rice: The straw yield of T. *Aman* rice was also significantly influenced by the Zn-B treatments. The straw yield ranged from 4.12 t ha^{-1} by control to 5.48 t ha^{-1} by $T_{3.1.1}$ treatment. Treatments $T_{1.1.1}$-$T_{3.1.1}$ contributed 11-24% higher straw yield over control ($T_{1.1.1}$). Treatment $T_{3.1.1}$ performed the maximum straw yield (5.48 t ha^{-1}) indicating that when the first crop (potato) received Zn at 4 kg ha^{-1} and B at 1.5 kg ha^{-1}, there was no need to further supply of Zn or Zn-B to the second (boro rice) and third crop (T. *Aman* rice). Applications of recommended rate of macronutrients with no micronutrient addition (control) showed the minimum straw yield (4.12 t ha^{-1}) of rice (Table 3).

Observing the effects of Zn-B treatments on the third crop (T. *Aman* rice, cv. Binadhan-7), it appeared that the treatment $T_{2.1.2}$ (Zn application at 2 kg ha^{-1} plus B addition at 1.5 kg ha^{-1} to the first crop- potato, with no application of these two elements to the second crop- *boro* rice, and addition only Zn at 2 kg ha^{-1} to the third crop- T. *Aman* rice) showed superior yield performances of T. *Aman* rice. In all crops, the control treatment having no Zn or B had the lowest yield.

The economic analysis shows that for the potato-*boro*-T. *Aman* cropping pattern, the $Zn_2B_{1.5}$-Zn_0B_0-Zn_0B_0 treatments combination showed the highest MBCR (16.2) that was followed by the $Zn_4B_{1.5}$ -Zn_0B_0-Zn_0B_0, (13.3 MBCR) and $Zn_2B_{1.5}$-Zn_0B_0-Zn_2B_0 combinations (13.2 MBCR) and $Zn_4B_{1.5}$-Zn_0B_0-Zn_2B_0 (10.2 MBCR) combinations. The other treatment combinations had MBCR in the range of 4.9-7.7 (Table 3).

Conclusion

Zn application at 4 kg ha^{-1} coupled with B application at 1.5 kg ha^{-1} to the first crop can meet their requirement for the subsequent two crops in the pattern. For the two rice crops in a pattern, B application at 1.5 kg ha^{-1} to the first crop and split application of Zn at 2 kg ha^{-1} to the first and third crops can give better yield benefit.

References

Bhuiyan, M.A.H., Khanam, D., Khatun, M.R., Hassan, M.S. 1998. Effect of molybdenum, boron and Rhizobium on nodulation, growth and yield of chickpea. Bull. Inst. Tropical Agric. Kyushu Unive. 21: 1-7.

Bhuiyan, M.A.H., Khanam, D., Khatun, M.R, Hassan, M.S. 1998. Effect of molybdenum, boron and Rhizobium on nodulation, growth and yield of chickpea. Bull. Instit. Tropical Agric., Kyushu Univ. 21: 1-7.

Cakmak, I. 2008. Enrichment of cereals grains with zinc: Agronomic and genetic biofortification? Plant Soil. 302(1-2): 1-17.

Fageria, N.K., Santos, A.B.D. and Cobucci, T. 2011. Zinc nutrition of lowland rice. Comm. Soil Sci. Plant Anal. 42(14): 1719-1727.

Gupta, S.P., Singh, M.V. and Dixit, M.L. 2007. Deficiency and management of micronutrients. Indian J. Fert. 3(6): 57–60.

Gupta, U.C. 1979. Boron nutrition of crops. 31: 273–307.

Hossain, M.A. 2007. Requirement of boron for mustard-mungbean-rice pattern and zinc for maize-mungbean-rice pattern in calcareous soil. PhD Dissertation, Department of Soil Science, Bangladesh Agriculture University, Mymensingh.

Hossain, M.A, Jahiruddin, M, Islam, M.R. andMian, M.H. 2008. The requirement of zinc for improvement of crop yield and mineral nutrition in the maize–mungbean–rice system, Plant Soil. 306(1): 13–22.

Hossain, M.S. 2005. Effects of different methods of zinc application on grain yield and grain zinc concentration of wheat genotypes. MS Thesis, Department of Soil Science, Bangladesh Agricultural University, Mymensingh.

Hussain, F. and Yasin, M. 2004. Soil fertility monitoring and management in rice-wheat system. Annual Report LRRP, NARC, Islamabad. pp. 1-33.

Jahiruddin, M. 2011. Screening, selection and molecular characterization of boron efficient wheat genotypes. Project Report, Department of Soil Science, BAU, Mymensingh.

Jahiruddin, M., Ali, M.S., Hossain, M.A., Ahmed, M.U. and Hoque, M.M. 1995. Effect of boron on grain set, yield and some other parameters of wheat cultivars.Bangladesh J. Agric. Sci. 22(1): 179-184.

Jahiruddin, M., Islam, M.N., Hashem, M.A. and Islam, M.R. 1994. Influence of sulphur, zinc, and boron on yield and nutrient uptake of BR-2. Progr. Agric. 5(1): 61–67.

Johnson, S.E., Lauren, J.G., Welch, R.M. and Duxbury, J.M. 2005. A comparison of the effects of micronutrient seed priming and soil fertilization on the mineral nutrition of chickpea *(Cicerarietinum),* lentil *(Lens culinaris),* rice *(Oryza sativa)* and wheat *(Triticum aestivum)* in Nepal. Exp. Agric. 41(04): 427-448.

Kay, R.D. 1981. Farm Management Planning Control and Implementation. McGraw-Hill Book company, New York, USA. p. 60.

Khalil, I.A., Muhammad, S., Iqbal, A. and Khattak, M.S. 2002. Yield and quality of potato as influenced by various levels of boron. Sarhad J. Agric. 18: 77-81.

Lora, R., Avila, O. and Rodriguez. 2002. Response of creole potato to sources and levels of boron on a soil of Cundinamarca (Colombia). Suelos Ecuatoriales. 32(1): 23-28.

Maharana, D.P., Sarengi, S.K., Singh, R.N.B. and Ali, M.H. 1993. Response of rice to application of zinc sulphate in different broad soil groups of Orissa. In Proc.: Micronutrients. 22-23 Jan. 1992, IBFEP, HFC, Bhubaneswar, Orissa, India pp. 228–262.

Metwally, A., El-Shazoly, R. and Hamada, A. M. 2012.Effect of boron on growth criteria of some wheat cultivars.J. Biol. Earth Sci. 2(1)**:** 1–9.

Nazli, F., Bibi, F., Gul, M. and Hannan, A. 2010. Effect of graded level of potassium on quality of potato crop. In: Abstracts 13th international congress of soil science, 24-27 March 2010, Faisalabad, Pakistan pp. 13.

Rashid, A., Muhammad, S. and Rafique, E. 2002. Genotypic variation in boron uptake and utilization in rice and wheat. In: All aspects of plant and animal nutrition. Goldbach, H. E., Rerkasem, B., Wimmer, M.A., Brown, P.H., Thellier, M., Bell, R.W. (Editors), Springer USA. pp. 305–310.

Rashid, A., Yasin, M., Ali, M.A., Ahmad, Z. and Ullah, R. 2009. Boron deficiency in rice in Pakistan: A serious constraint to productivity and grain quality. *In:* Salinity and water stress: Improving crop efficiency, Ashraf, M., Ozturk, M., Athar, H. R. (Editors), Springer-Verlag, Berlin-Heidelberg, Germany. pp. 213–219.

Saleem, M., Yusop, M.K., Ishak, F., Samsuri, A.W. and Hafeez, B. 2011. Boron fertilizers borax and colemanite application on rice and their residual effect on the following crop cycle.Soil Sci. Plant Nutr. 57(3): 403–410.

Segura, A., Trivino, A.L. and Silva. 2007. Creole potato *(Solatium phureja* Justet Buk*)* behavior to calcium and boron in a soil of Cundinamarca, Colombia. Revista UDCA Actualidad and Divulgacion Cientifica, Colombia**.** pp.275-284.

SRDI. 2008. GIS map, Zinc status of Bangladesh soils. SRDI, Farmgate, Dhaka.

SRDI. 2010. GIS map, Boron status of Bangladesh soils, SRDI, Farmgate, Dhaka.

Srivastava, S.P., Bhandari, T.M.S., Yadav, C.R., Joshi, M. and Erskine, W. 2000. Boron deficiency in lentil: yield loss and geographic distribution in a germplasm collection. Plant Soil. 219: 147-151.

Taheri, N., Abad, H.S., Yousefi, K. and Mousavi, S.R. 2011. Effect of organic manure with phosphorus and zinc on yield of seed potato. Australian J. Basic Appl. Sci. 5**:** 775–780.

Zaman, M.W., Rahman, S.H., Morzia, B.A. and Ahmed, S. 1994. Phosphorus and zinc interaction in rice grain. Progr. Agric. 5: 273–278.

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RESPONSE OF FINE GRAIN AMAN RICE TO DIFFERENT LEVELS OF NITROGEN AND POTASSIUM

M. M. A. Mondal

Abstract

Four field experiments were conducted at HQ farm, Mymensingh and Sub-station farms at Magura, Ishurdi and Comilla of the Bangladesh Institute of Nuclear Agriculture during the period from July to December 2009 to study the effect of different rate of nitrogen and potassium application on morphological, biochemical and yield of fine grain rice *cv*. RM 100-16. The experiment comprised of four levels of nitrogen fertilizer *viz*., 0, 25, 50 and 75 kg N ha^{-1}, and four levels of potassium application *viz*. 0, 15, 25 and 35 kg K ha^{-1}. The experiment was laid out in a split-plot design with three replications where nitrogen levels placed in the main plot and potassium levels in the sub-plots. The highest grain yield was recorded in 50 kg N ha^{-1} (25.82 g $hill^{-1}$ and 3.29 t ha^{-1}) due to superior growth, biochemical parameters and higher number of effective tillers $hill^{-1}$ (19.2) and filled grains $panicle^{-1}$ (170.6). However, the highest harvest index was recorded in 25 kg N ha^{-1} (43.54%). For potassium effect, results revealed that most of the morpho-physiological parameters and yield attributes increased up to 25 kg K ha^{-1}. The highest grain yield was recorded in 25 kg K ha^{-1} (21.83 g $hill^{-1}$ and 2.93 t ha^{-1}) due to production of higher number of effective tillers $hill^{-1}$ (14.6) and filled grains $panicle^{-1}$ (160.0). In contrast, control plant produced the lowest yield due to inferior growth, biochemical parameters and yield attributes. For combined effect of nitrogen and potassium, results revealed that 50 kg N ha^{-1} with 25 kg K ha^{-1} produced the highest grain yield (27.02 g $hill^{-1}$ and 3.68 t ha^{-1}) followed by $N_{50} \times K_{35}$ (26.00 g $hill^{-1}$ and 3.40 t ha^{-1}).

Key words: Nitrogen, potassium, biochemical parameter, grain yield, rice

Introduction

In Bangladesh, rice (*Oryza sativa* L.) is grown in Aus (pre-monsoon, April to June), Aman (Monsoon, July to November) and Boro (dry season irrigated, December to May) seasons. Among the Aman rice cultivars, fine grain rice cultivars have occupied about 12.5% of the total Aman rice cultivation (BBS, 2015). Although the quality and taste of many types are appreciated and used for preparation of special dishes, the main drawback of these fine grain rice cultivars is their poor grain yield and longer duration of maturity. However, fine grain rice has more demand both in internal and external trade markets. Moreover, the price of one-kilogram aromatic fine milled rice is usually more than coarse modern rice. Therefore, the production of aromatic rice in our country is becoming popular due to its high price and export potentiality (Dutta *et al*., 2002).

Crop Physiology Division, Bangladesh Institute of Nuclear Agriculture, Mymensingh-2202, Bangladesh.

The reasons for low yield in fine grain rice are manifold: some are varietal, some are climatic and some are agronomic management. Due to the shortage of land, the scope for extension of its cultivation is very limited. Therefore, attempts must be made to increase the yield per unit area by applying improved technology and management practices. The yield of fine grain transplant *Aman* rice can be increased with the improved cultivation practices like proper spacing and time and rate of nutrients application.

Among the fertilizer elements, nitrogen plays a key role in rice production and it is required in larger amount compared to other fertilizers. It affects the vegetative growth, development and yield. The important role of nitrogenous fertilizer in increasing rice yield has been widely recognized (Puteh and Mondal, 2014). Rice yield may be increased by 70 to 80 per cent by proper utilization of nitrogen fertilizer (Patil and Mishra, 1994). The efficient fertilizer management can increase crop yield and reduce production cost. Excess amount of nitrogen fertilizer results in lodging of plant, prolonging growing period, delaying maturity and reducing yield (Puteh and Mondal, 2014). Non-judicious application of nitrogen fertilizer not only increases production cost but also reduces the quality of the product. So, it is necessary to find out the suitable rate of nitrogen fertilizer for efficient management and better yield of fine grain rice.

Potassium (K) is one of the primary as well as the third so called major nutrient element for plant growth and development. Lack of K restricts the establishment, development, and yield of crops (Rengel and Damon, 2008). K is required for the activity of many enzymes, including those of energy metabolism, protein synthesis, and solute transport. Many workers have reported a significant response of rice to K fertilizer (Pal, 2005; Moro *et al*., 2008, Jalali-Moridani and Amiri, 2014; Islam *et al.*, 2015). Application of potassium at an optimum level promoted photosynthetic activity which enhance grain yield (Rao *et al*., 1990). For fine grain rice, the information is limited on the effect of potassium fertilizer application on biochemical parameters, growth and yield. It is, therefore, necessary to do extensive research on fine grain rice. Keeping the above view in mind, the experiment was taken to assess optimum level of nitrogen and potassium for maximizing the grain yield of fine grain rice; and to find out suitable combination of nitrogen and potassium levels for maximizing grain yield of fine grain rice.

Materials and Methods

Four field experiments were conducted at the experimental farms of BINA HQ, Mymensingh and sub-station farms at Comilla, Magura and Ishurdi during T. aman season of 2009 to find out the response of fine grain rice to different levels of nitrogen and potassium application on morpho-physiological and yield attributes and yield. A promising mutant line, RM 100-16 was used as a planting material. The experiment comprised of four levels of nitrogen viz., 0, 25, 50 and 75 kg ha^{-1} and four levels of potassium viz., 0, 15, 25 and 35 kg ha^{-1}. The experiment was laid out in a split-plot design with three replications where nitrogen levels placed in the main plot and potassium levels in the sub-plots. The unit plot size was 3m × 2.5m. The soil of the experimental plots at Mymensingh and Comilla was clay loam, at Magura and Ishurdi was sandy loam.

Nitrogen was applied in the form of urea and potassium was applied in the form of muriate of potash. Total amount of triple super phosphate, mutriate of potash and gypsum were applied as basal dose during final land preparation and urea was top dressed in two equal splits at 15- and 45 days after transplanting. The triple superphosphate and gypsum were applied at the rate of 50 and 40 kg ha^{-1}, respectively. Thirty day-old seedlings were transplanted on 22 July 2009 at the rate of 2 seedlings per hill maintaining spacing of 20 cm × 20 cm. Gap filling was done within a week of transplanting. Two hand weedings were done at 25 and 50 DAT. Pesticides were used to control leaf hopper. Other intercultural operations were done as and when necessary. Chlorophyll, total sugar, amino acid and nitrate reductase activity in leaves were taken only from BINA HQs farm (Mymensingh). Leaf Chlorophyll was determined following the method of Yoshida *et al*. (1976). Nitrate reductase activity was determined following the methods of Stewart and Orebamjo (1979). Total sugar and amino acid were determined following the method of Badruddin (2005). At harvest, the morphological and yield attributes were recorded from ten sample hills of each plot at all four locations. The grain and straw yield were collected from whole plots and converted into t ha^{-1}. The collected data were analyzed statistically following the analysis of variance technique and the mean differences were adjudged with Duncan's Multiple Range Test using the statistical computer package program, MSTAT (Russell, 1986).

Results and Discussion

Effect of nitrogen and potassium on morphological parameters:

The effect of different doses of N application was significant on plant height, number of effective and non-effective tillers hill^{-1}, leaf area and straw weight hill^{-1} (Table 1). Results revealed that plant height, number of effective tillers hill^{-1}, leaf area and straw weight hill^{-1} increased significantly with increasing nitrogen doses till 50 kg N ha^{-1} followed by the increment was not significant in most cases. Number of non-effective tillers was lower in 25 and 50 kg N ha^{-1} than in 0 and 75 kg N ha^{-1}. The lowest plant height, number of effective tillers hill^{-1}, leaf area and straw weight hill^{-1} was recorded in control plants where no N was applied. The increased plant height, tiller number, leaf area and straw weight in high doses of N as compared to low doses of N might be due to getting available N at early vegetative stage which helps in better growth and development of the rice plants. This result is consistent of Jalali-Moridani and Amiri (2014) who reported that plant height and total dry mass increased in high dose than in low dose of N in rice.

The effects of potassium (K) doses on plant height, number of effective and non-effective tillers hill^{-1}, leaf area and straw weight hill^{-1} was significant (Table 1). Results revealed that plant height, number of effective and non-effective tillers hill^{-1}, leaf area and straw weight hill^{-1} was greater in K applied plants than in control plants. But within the K levels, there was no significant difference of the studied morphological parameters. The highest effective tillers, leaf area and straw weight plant^{-1} was observed in 35 kg K ha^{-1}

Table 1. Effect of nitrogen and potassium on morpho-physiological characters in fine grain rice mutants, RM 100-16 grown at Mymensingh

Treatment	Plant height (cm)	Effective tillers hill^{-1} (no.)	Non-effective tillers hill^{-1} (no.)	Leaf area hill^{-1} (cm^2)	Straw weight hill^{-1} (g)
N-levels					
0	112.4 c	5.38 d	6.19 a	346.3 d	28.11 c
25	147.7 b	13.0 c	4.56 b	564.5 c	54.92 b
50	159.8 a	19.2 a	4.51 b	792.5 b	67.81 a
75	158.4 a	18.1 b	6.13 a	816.8 a	68.91 a
Level of sig.	**	**	**	**	**
K-levels					
0	139.8 b	12.5 b	5.88 b	573.3 c	50.19 b
15	145.5 a	14.6 a	4.75 c	622.5 b	55.82 a
25	147.3 a	14.2 a	4.01 d	656.8 a	56.27 a
35	145.8 a	14.3 a	6.75 a	667.5 a	57.48 a
Level of sig.	*	**	**	**	**
CV (%)	4.88	7.22	5.40	4.48	4.32

In a column, figure (s) with same letter dot not differ significantly at $P \leq 0.05$; ** Significant at 1% level of probability.

followed by 25 kg K ha^{-1} with same statistical rank. These results indicate that 25 kg K ha^{-1} is sufficient for normal growth and development in fine grain rice. In contrast, the lowest plant height, number of effective tillers, leaf area and straw weight hill^{-1} was observed in control plants where no K was applied. Rao *et al.* (1995) reported that plant morphological characters increased with increasing K levels till 40 kg K ha^{-1} that supported the present experimental result.

Effect of nitrogen and potassium on biochemical parameters:

The effect of nitrogen and potassium levels on biochemical parameters such as chlorophyll, nitrate reductases, total sugar and amino acid content in leaves was significant (Table 2). Results revealed that biochemical parameters significantly increased with increasing nitrogen levels till 50 kg N ha^{-1}and further increment of N level (75 kg N ha^{-1}) increased non-significantly over earlier dose (50 kg N ha^{-1}) of the said biochemical parameters. These results indicate that 50 kg N ha^{-1} is sufficient for normal biochemical activities of fine grain rice. In contrast, the lowest chlorophyll (1.75 mg g^{-1} fw), nitrate reductase (3.41 μ mol NO_2 g^{-1} fw), total sugar (5.50 mg g^{-1} fw) and amino acid (13.10 mg g^{-1} fw) content in leaves were observed in control plant where no nitrogen was applied. Similar results were also observed in case of K levels (Table 2). The optimum dose of K for biochemical activities was observed in 25 kg K ha^{-1} and 35 kg K ha^{-1} seems be luxurious for fine grain rice.

Table 2. Effect of nitrogen and potassium on biochemical parameters in fine grain rice mutants, RM 100-16 grown at Mymensingh

Treatment	Chlorophyll (mg g^{-1} fw)	Nitrate reductase (µmol NO_2 g^{-1} fw)	Total sugar (mg g^{-1} fw)	Amino acid (mg g^{-1} fw)
N-levels				
0	1.75 d	3.42 c	50.50 c	13.10 c
25	1.91 bc	4.12 b	71.23 b	18.97 b
50	2.15 ab	4.82 a	74.73 a	21.58 a
75	2.28 a	4.99 a	74.46 a	21.88 a
Level of sig.	**	**	**	**
K-levels				
0	1.98 c	4.18 b	56.55 c	13.70 c
15	2.03 b	4.37 a	66.65 b	19.18 b
25	2.09 a	4.42 a	73.02 a	21.05 a
35	2.09 a	4.38 a	74.68 a	21.60 a
Level of sig.	**	**	**	**
CV (%)	3.22	3.70	4.39	7.51

In a column, figure (s) with same letter dot not differ significantly at $P \leq 0.05$; ** Significant at 1% level of probability.

Effect of nitrogen and potassium on yield attributes and yield:

The effects of nitrogen and potassium on yield attributes and grain yield such as number of grains panicle^{-1}, 1000-grain weight, harvest index and grain yield were significant (Table 3). Results indicated that number of grains panicle^{-1}, 1000-grain weight and grain yield hill^{-1} increased with increasing N levels until 50 kg N ha^{-1} followed by a decline. The highest grain yield (25.82 g) was recorded in 50 kg N ha^{-1} due to production of higher number of grains (170.6) panicle^{-1} and increased 1000-grain (11.23 g) weight. The grain yield was lower with 75 kg N ha^{-1} because of plant lodged after booting phase for over growth (visual observation, data not shown). The lowest grain weight hill^{-1} was recorded in control plants, where no N fertilizer was applied. However, the highest harvest index (43.54 %) was observed in 25 kg N ha^{-1} indicating dry matter partitioning to economic was good at this N level. These results are in conformity with those of Murky *et al.* (1992) who reported that zero or lesser amount of N application had the lowest number of filled grains panicle^{-1} compared to higher doses in rice.

The number of grains panicle^{-1}, 1000-grain weight and harvest index was the highest in 25 kg K ha^{-1} resulting the highest grain yield hill^{-1}. And further increment of K level (>25 kg K ha^{-1}) decreased yield attributes and grain yield. These results indicate that 25 kg K ha^{-1}is optimum for getting maximum yield potential of fine grain rice. Variations in grain yield due to different levels of potassium application were observed by Islam *et al.* (2015) in rice. In case of grain yield over locations, results revealed that three locations such as Mymensingh, Ishurdi and Comilla, the grain yield performance due to different levels of N and K were also most similar i. e. the grain yield increased with increasing N levels till 50 kg N ha^{-1} and K levels till 25 kg N ha^{-1} followed by a decline whereas at Magura, the grain yield increased with increasing N levels up to 75 kg N ha^{-1} and K level up to 35 kg K ha^{-1} because of plant growth was poorer at Magura than the other locations, Mymensingh, Ishurdi and Comilla (visual observation, data not shown in Table).

Table 3. Effect of nitrogen and potassium on yield attributes and yield in fine grain rice mutants, RM 100-16 (average over four locations)

Treatment		Grains panicle^{-1} (no.)	1000-grain weight (g)	Grain yield hill^{-1} (g)	Harvest index (%)
N-levels	0	113.8 d	10.65 c	10.84 d	38.52 b
	25	158.4 b	11.07 b	23.89 b	43.54 a
	50	170.6 a	11.41 a	25.82 a	38.11 b
	75	138.3 c	11.23 a	20.64 c	29.93 c
Level of sig.		**	**	**	**
K-levels	0	116.9 c	10.92 b	18.42 c	37.51 ab
	15	149.9 b	11.03 ab	20.13 b	36.65 b
	25	160.0 a	11.23 a	21.81 a	38.90 a
	35	154.3 ab	11.18 a	20.83 b	37.04 b
Level of sig.		**	*	**	*
CV (%)		8.11	2.78	6.40	5.88

In a column, figure (s) with same letter dot not differ significantly at $P \leq 0.05$;
*, ** Significant at 5% and 1% level of probability, respectively.

Interaction among location, nitrogen and potassium rate on yield:

For interaction effect of location, nitrogen and potassium, results revealed that at three locations such as Mymensingh, Ishurdi and Comilla, the highest grain yield was observed when 50 kg N ha^{-1} along with 25 kg K ha^{-1} was applied (Table 4). The second highest grain yield was recorded in 50 kg N ha^{-1} with 35 kg K ha^{-1}. At Magura, the highest grain yield was observed in 75 kg N ha^{-1} with 35 kg K ha^{-1}. The lowest grain yield was found in 0 kg N ha^{-1} with 0 kg K ha^{-1} at all four locations.

Table 4. Interaction effect of nitrogen and potassium levels on grain yield conducted at four locations

Interaction		Grain yield (t ha^{-1}) at				
		Mymensingh	Ishurdi	Comilla	Magura	Mean
N_0	K_0	1.81 i	1.84 g	2.00 gh	1.67 d	1.83 i
	K_{15}	2.08 hi	2.21 f	2.03 g	1.96 gh	2.07 h
	K_{25}	2.22 gh	2.33 ef	2.26 fg	2.06 g	2.22 gh
	K_{35}	2.47 g	2.32 ef	2.50 f	2.00 g	2.27 g
N_{25}	K_0	2.82 de	2.37 ef	3.17 e	2.20 fg	2.58 ef
	K_{15}	3.23 bc	2.45 ef	3.57 cd	2.50 ef	2.84 cd
	K_{25}	3.43 ab	2.52 ef	3.83 bc	2.60 de	2.98 c
	K_{35}	3.13 c	2.88 cd	3.40 de	2.72 cde	3.00 c
N_{50}	K_0	3.21 bc	2.42 ef	3.17 e	2.56 de	2.71 de
	K_{15}	3.42 ab	3.19 abc	4.07 ab	2.85 cd	3.37 b
	K_{25}	3.56 a	3.52 a	4.23 a	3.30 ab	3.68 a
	K_{35}	3.43 ab	3.42 a	3.83 bc	2.96 c	3.40 b
N_{75}	K_0	2.48 f	2.62 de	2.00 gh	2.73 cde	2.45 f
	K_{15}	2.59 ef	3.04 bc	2.22 fg	3.00 bc	2.75 de
	K_{25}	3.04 cd	3.25 ab	1.92 gh	3.35 a	2.84 cd
	K_{35}	2.79 de	2.90 cd	1.67 h	3.30 ab	2.62 ef
CV (%)		9.55	30.82	12.14	10.5	17.30

In a column, same letter (s) do not differ significantly at $P \leq 0.05$

Based on the experimental results, it may be concluded that application of nitrogen and potassium has tremendous effect on growth, biochemical parameters and yield in fine grain rice; and application of 50 kg N ha^{-1} with 25 kg K ha^{-1} appears to be the best combination for getting maximum yield of fine grain rice in land belonging to the Sonatola Soil Series of Grey Floodplain soilunder the agro-ecological zone of Old Bahmaputra Flood plain (AEZ-9).

References

Badruddin, M. 2005. Laboratory manual for plant and soil sample analysis. Bangladesh Institute of Nuclear Agriculture, P. O. Box # 4, Mymensingh, Bangladesh. pp. 25-27.

BBS (Bangladesh Bureau of Statistics). 2015. Monthly Statistical Bulletin of Bangladesh. October, 2009. Stat. Div., Minis. Plan., Govt. Peoples's Repub. Bangladesh, Dhaka. p.67.

Dutta, R.K., Mia, M.A.B and Khanum, S. 2002. Plant architecture and growth characteristics of fine grain and aromatic rice and their relations with grain yield. Inst. Rice Comm. Newsl. 51: 51-55.

Islam, A., Chandrabiswas, J., Karim, A.J.M.S., Salmapervin, M., and Saleque M.A. 2015. Effects of potassium fertilization on growth and yield of wetland rice in Grey Terrace Soils of Bangladesh. Res. Crop Ecophysiol. 10: 64-82.

Jalali-Moridani, M. and Amiri, E. 2014. Effect of nitrogen and potassium on yield and yield components of rice cultivar "Hashemi". Indian J. Fund. Appl. Life Sci. 4: 417-424.

Moro, B.M., Nuhu, I.R. and Toshiyuki, W. 2008. Determing optimum rate of mineral fertilizers for economic rice grain yield. West African J. Appl. Ecol. 12: 45-51.

Murty, P.S.S., Ramesh, K.S., Rao, G.V.H. and Narayanan, A. 1992. Influence of nitrogen on grain filling potential and yield of rice varieties. Indian J. Agron. 37: 175-178.

Pal, D.K. 2005. Role of potassium for early rice growth and development. Clay Res. 24:223-232.

Patil, S.R. and Mishra, N.N. 1994. Effect of different forms of urea and levels on the yield and nitrogen uptake of rice. Adv. Plant Sci. 7 (2): 327-331.

Puteh, A.B. and Mondal, M.M.A. 2014. Appropriate time and rate of nitrogen application on grain yield in rice. J. Progr. Sci. Technol. 12 (1): 113-116.

Rao, T.T., Singh, J.V. and Roy, A.K. 1990. Role of K on growth and yield in rice. J. Agric. Res. 28: 25-32.

Rao, T.T., Singh, J.V. and Roy, A.K. 1990. Role of K on growth and yield in rice. J. Agric. Res. 28: 25-32.

Rengel, Z. and Damon, P.M. 2008. Crops and genotypes differ in efficiency of potassium uptake and use. Physiol. Plant.133: 624–636.

Russell, D.F., 1986. MSTAT-C computer package programme," Crop and Soil Science Department, Michigan State University, USA.

Stewart, G.R. and Orebamjo, T.O. 1979. Some unusual characteristics of nitrate reduction *Erythrana senegalensis*. *New Physiol*. 83: 311-319.

Yoshida, S., Forno, D.A., Cock, J.A. and Gomes, K.A. 1976. Laboratory manual for physiological studies of rice. 3rd ed., IRRI, Los Banos, Philippines.

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POPULATION OF *FUSARIUM OXYSPORUM* OF TOMATO WILT DURING OVERWINTERING PERIOD

M. K. Hasna, M. A. Kashem, M. I. Khalil and H. A. Begum

Abstract

An experiment was conducted at Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh during 2014-15. Twenty two days old seedlings of Binatomato-3 were transplanted in pot soil infested with *F. oxysporum* f. sp. *lycopersici*. Soil samples were collected from infested pots at 5, 10, 15, 20, 25 and 30 days after transplantation (DAT). After harvesting the pots were kept under natural condition for three months. Then soil sample was collected for five months. *F. oxysporum* f. sp. *lycopersici* was isolated from soil sample by dilution plate technique. The colony number of *Fusarium* was minimum (30.4 CFUx10^3/g soil) at 5 DAT. The number gradually increased up to 20 DAT and at the end of 20 DAT the colony number was 73.43 CFUx10^3/g soil. The average colony number of *Fusarium* was significantly higher in the 2nd than that of 1st, 3rd, 4th and 5th month. Thus, the inocula of *F. oxysporum* f. sp. *lycopersici* was viable in soil without host plant and the amount of inocula of the fungus was variable in different months of the year.

Key words: *Fusarium oxysporum*, tomato, over wintering

Introduction

Tomato is an important and popular vegetable all over the world. it is cultivated in almost all countries of the world. The cultivated area under tomato in Bangladesh is 17814 hectares with an average yield of 6.92 t ha^{-1} (BBS, 2015). The production of tomato in Bangladesh is low in comparison to that of other leading tomato producing countries. Several factors are involved in low production of tomato in Bangladesh. Among the factors diseases caused by fungi, bacteria, viruses and nematodes are mentionable. About 200 diseases of tomato crop all over the world have been reported (Watterson, 1986). Among them wilt caused by *Fusarium oxysporum* f. sp. *lycopersici* is an important soil borne disease of tomato which causes significant yield losses in susceptible cultivars. The infection occurs through fine rootless and the fungus enters the host vascular system leading to yellowing of leaves, wilting and collapse of the root system (Karimi *et al.*, 2012). *F. oxysporum* f. sp. *lycopersici* survives in the soil as a saprophyte in absence of the host plant. The fungus over winters as chlamydospores which persist for longer period. The population of this soil borne fungus are different in different time of the year and are influenced by cropping pattern, crop rotation, intercropping etc. (Peterson *et al.*, 2002) Temperature, soil type, water retentive nature of the soil and nutrient availability has been shown to affect

Plant Pathology Division, Bangladesh Institute of Nuclear Agriculture, Mymensingh 2202, Bangladesh

Fusarium population (Reddy, *et al*., 1993; Landa *et al*., 2009, Saremi and Burgess, 2010). So, the elimination of this fungus is not easy. However, the information about the survivability of *F. oxysporum* f. sp. *lycopersici* is important for the management of this pathogen. Therefore, the study was undertaken to observe the presence and pathogenicity of the inocula of *F. oxysporum* f. sp. *lycopersici* in nature in absence of the host plant. From the finding we would be able to know status of the population of *Fusarium* during overwintering period.

Materials and Methods

A pot experiment was conducted at the farm of Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh during 2014-15. The experiment was laid out in Completely Randomized Design (CRD) with four replications.

Preparation of Pure culture F. oxysporum* f. sp. *lycopersici:

Fusarium wilt infected plant parts were collected from tomato field. The disease samples were cut into small pieces including healthy and diseased tissue. The pieces were surface sterilized with 5% chlorox (sodium hypochloride) for one minute and were rinsed in sterile water for two times. Two sterilized pieces were placed in PDA plates. The plates were incubated at 25^0C for seven days to grow the pathogen. The fungus *F. oxysporum* f. sp. *lycopersici* was observed under microscope and was identified according to Barnett (1965). Pure culture was prepared by transferring hyphal tip to another PDA plates and was stored at refrigerator (5-6^0C) for further use.

***Preparation of mass inocula of F. oxysporum* f. sp. *lycopersici*:**

Chick pea bran was soaked in water for 12 hours. Around 20g chick pea bran was taken in a conical flask of 500 ml and was autoclaved at 120^0C under 15 lbs for 30 minutes. The sterilized substrate in the conical flask was inoculated with 5 mycelial disc (5 mm diameter) of 3 days old culture of *F. oxysporum* f. sp. *lycopersici* previously grown on PDA. The flasks were incubated at 25^0C for 15 days with intermittent hand shaking at 5 days.

Pot experiment:

A pot experiment was carried out by artificial inoculation of *F. oxysporum* f. sp. *lycopersici.* Soil was collected from the field of BINA farm, Mymensingh and dried in the sun for two days. The dried soil was mixed uniformly with well decomposed cowdung at 2:1 (soil: cowdung). The soil-cowdung mixture was sterilized with formalin at the rate of 5 ml formalin diluted with 20 ml of water for 4 kg substrate. The formalin treated soil was covered with polythene sheet for 72 hours. Afterwards the polythene sheet was removed and the soil was kept open for aeration for 5 days. Four kg of soil was filled in a plastic pot. Ten g of inocula of *F. oxysporum* f. sp. *lycopersici* grown on chickpea bran was mixed well in each pot within 6 inch depth soil. Eighteen pots were inoculated and three pots were kept as control without adding inocula. The pots were kept in undisturbed condition for 4 days for well growth of *Fusarium* in the soil. After four days of inoculation, 20 days old tomato seedlings were transplanted in the pot. The cultivar Binatomato-3 was used in the experiment. The seeds were collected from BINA and seedlings were grown in the soil within a tray. In each pot one seedling was transplanted. Pots were kept under natural condition. Watering was done as per requirement.

Isolation of F. oxysporum f.* sp. *lycopersici from soil:

For the isolation of *F. oxysporum f.* sp. *lycopersici* from soil, first collection of soil sample was done at 5 days after transplantation. The sample collection continued for 30 days with 5 days interval. While developing disease symptom of wilt, the infected plant was uprooted and washed properly with tap water to remove the soil. The infected plant parts were preserved in the refrigerator. After harvesting the pots along with soil were kept in natural condition under a shade. Soil sample from the inoculated pot was collected in every month. First sample was collected in June and continued up to October. In each month soil sample was collected from three inoculated pots and control pots.

Ten gram of soil was placed in test tube containing 90 ml of sterile water and shaken thoroughly for few minutes in order to obtain a uniform suspension. A total 10 fold dilution from 10^{-1} to 10^{-5} was prepared. Plating was done from 10^{-3} dilution. From that dilution 1 ml suspension was transferred on a PDA plate. There were six replications for each soil sample. After adding the suspension the plates were shaken by giving swirling motion for few minutes in order to disperse fungal spores and mycelia fragments uniformly. Inoculated plates were incubated at 25^0C for 4 days. Then the appearing fungal colonies of *F. oxysporum* f. sp. *lycopersici* were counted. The average number of colonies was expressed by per gram of soil.

Pathogenicity test of F. oxysporum* f. sp. *lycopersici isolated from soil and plant parts of tomato:

Isolated pure culture of *F. oxysporum* f. sp. *lycopersici* from soil and plant parts of tomato was suspended with water for conidial suspension. The culture of the fungus from PDA plate (15 Plates of 7 days old culture of *F. oxysporum*) were scraped and poured in 750 ml water. Then it was blended for one minute. The conidial suspension then filtered through cheese cloth to remove mycelia suspension. A suspension of 10^6 conidia/ml was prepared according to Gilchirst (1985). Then a suspension of 15 ml was taken in a test tube. One seedling of the cultivar Binatomato-3 of 14 days old was transferred in the test tube. The upper part of the tube was wrapped with wet cotton and kept undisturbed. Thirty two tubes with conidial suspension were prepared while eight tubes were poured with sterilize water as control. Data of seedling infection was taken after 2, 3, 4 and 6 days of seedling transfer. Every time data from eight tubes with inocula suspension was taken and seedling infection was expressed as percentage.

Results and Discussion

Colony number of *F. oxysporum* f. sp. *lycopersici* in the infested soil in presence of tomato plants at different Days After Transplantation (DAT) was recorded (Table 1). Lowest colony number of *F. oxysporum* f. sp. *Lycopersici* (30.4 CFUx10^3/g soil) was found at 5 Days After Transplantation (DAT). Then the number gradually increased up to 20 DAT and at the end of 20 DAT the colony number was 73.43 CFUx10^3/g soil. After 20 DAT there was a continual decline of the colony number until 30 DAT. The reduction in cfu of *Fusarium solani* with increased duration of incubation was reported (Prasad and Saifullah, 2012; Mallesh and Narendrappa, 2008).

Table 1. Number of colony of *F. oxysporum* f. sp. *lycopersici* in the infested soil at different days after transplantation in the presence of tomato plant

Days After Transplantation (DAT)	Mean colony number CFU (x10^3/g soil)
5	30.40 c
10	39.76b
15	71.67a
20	73.43a
25	39.67b
30	38.90b

Mean follows by the same letter do not differ significantly at the 5% level.

The average colony number of *F. oxysporum* f. sp. *lycopersici* in the infested soil In absence of tomato plant at different months was varied significantly (Table 2). The maximum number of colony was found in the 2nd month. In the 2nd month the colony number was maximum (49.7 CFUx10^3/g soil) at 25 DAT and minimum at 5 DAT (31.6 CFUx10^3/g soil). The average colony number in 1st month was maximum (39.2 CFUx10^3/g soil) at 25 DAT and minimum 22.0 CFUx10^3/g soil at 5 DAT, in the 3rd month it was maximum (34.3 CFUx10^4/g soil) at 25 DAT and minimum 15.0 CFUx10^3/g soil at 5 DAT. In the 4th month it was maximum (43.2 CFUx10^3/g soil) at 25 DAT and minimum 10.3 CFUx10^3/g soil at 5 DAT, in the 5th month it was maximum (43.7 CFUx10^3/g soil) at 30 DAT and minimum 9.7 CFUx10^3/g soil at 5 DAT. In the 2nd month the average colony number of *F. oxysporum* f. sp. *lycopersici* was significantly higher than that of 1st, 3rd, 4th and 5th (Fig. 1). Indeed, temperature and water potential and their interactions are main factors in managing fungal population in soil (Reddy *et al.*, 1993). In our experiment the indicating 2nd month was July and it was the monsoon time. It is possible that high soil moisture with warm temperature was responsible for high population of *F. oxysporum* f. sp. *lycopersici* in July in the experiment. The influence of temperature and water potential on the population dynamics of *Fusarium* species in soil is reported by Prasad and Saifullah (2012).

Table 2. Number colony of *F. oxysporum* f. sp. *lycopersici* in the infested soil in different months in absence of tomato plants

Days After Transplantation (DAT)	Number of colony CFU (x10^3/g soil)				
	1st month	2nd month	3rd month	4th month	5th month
5	22.0f	31.6c	15.0e	10.3f	9.7d
10	29.4e	50.6b	19.0d	16.6e	12.6d
15	56.7b	67.7a	41.4b	29.3c	37.2c
20	63.4a	61.4a	60.3a	54.3a	21.3a
25	39.2c	49.7b	34.3c	43.2b	43.7b
30	32.5d	41.4b	18.3d	23.6d	21.6c

Number of colony is the average of six replications and number follows by the same letter do not differ significantly at the 5% level

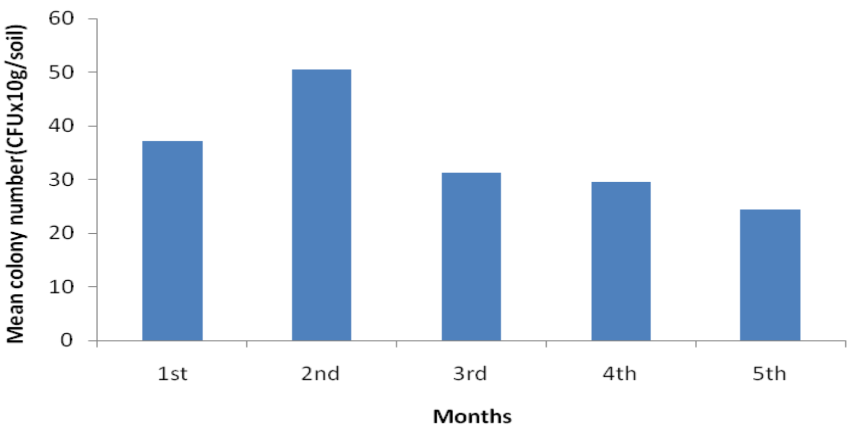

Fig. 1. Mean colony number of *F. oxysporum* f. sp. *lycopersici* in the infested soil in different months in absence of tomato plants

After harvest of tomato plants the infected plants were kept for 3 months under natural condition. The plant samples were tested for the viability of the inocula of *F. oxysporum* f. sp. *lycopersici*. Conidial suspension (5.5x10^6) was prepared with *F. oxysporum* f. sp. *lycopersici* isolated from soil and tomato plant parts. To observe disease infection tomato seedlings of 15 days old were growing in the conidial suspension in test tubes (Table 3). Thirty percent seedlings showed infection at two days, 45% seedlings showed infection at 3 days. After 4 days 60% seedlings were infected and after 5 days all the seedlings were infected. There was no infection in the control. The presence of the viability of the isolated inocula of *F. oxysporum* f. sp. *lycopersici* was confirmed by the pathogenecity test. Fenny (1978) developed disease symptom upto 60-80% on three week old tomato seedlings by dipping the root of tomato seedlings in micro conidial suspension of *Fusarium oxysporum*.

Table 3. Number of seedlings (%) infected by *F. oxysporum* f. sp. *lycopersici* in test tube under pathogenicity test

Treatment	No. of tested seedlings	Infected seedlings (%) at different days after transferring seedling			
		2 days	3 days	4 days	6 days
Seedlings in conidial suspension	8	30	45	60	100
Seedlings in water (without conidia)	8	0 (no infected seedling)	0 (no infected seedling)		0 (no infected seedling)

In conclusion it is said that the inocula of fungus *F. oxysporum* f. sp. *lycopersici* which was used in our experiment was viable in soil without host plant. The amount of inocula of the fungus was different in different months of the year. Thus *F. oxysporum* f. sp. *lycopersici* the causal agent of tomato wilt can over winter in the soil during off season of tomato plants and in presence of the host plant it can produce wilt disease on tomato plants.

References

Barnett, H.I. 1965. Illustrated Genera of Imperfect fungi. Burgress Publishing Co. p. 225.

BBS. 2015. Statistical Yearbook of Bangladesh. Bangladesh Bureau of Statistics. Ministry of Planning, Government of People's Republic of Bangladesh, Dhaka, Bangladesh.

Fenny, D. 1978. Pathogenecity of soil borne pathogens.Annual Rev. Plant Pathol. 44: 128.

Gilchrist, L.I. 1985. CIMMYT method for screening wheat for *Helminthosporium sativum* resistance. Institute of Mexico CIMMYT. pp. 149-151.

Karimi, R., Owuoche, J.O. and Silim, S.N. 2012. Importance and management of fusarium wilt (*Fusarium udum* Butler) of pigeonpea. Int. J. Agron. Agril. Res. 2: 1-14.

Landa, B.B., Cortes N., Hervas, J.A., Jimenez A. and Diaz, R.M. 2009. Influence of temperature and inoculum density of *Fusarium oxysporum* f. sp. *ciceris* on suppression of Fusariun wilt of chickpea by rhizosphere bacteria. Departyamento de Proteccion de Cultivos, Instituto de Agricultura Sostenible (IAS), Spain. 91:807-816.

Mallesh, S.B. and Narendrappa, T. 2008. Effect of different depths of soil and host range studies on survivability of *Fusarium solani*, the causal agent of root rot of sage (*Salvia officinalis* L.). Int. J. Plant Sci. 3: 298-300.

Peterson, S.S., Foohne, P.S. and Kennedy, A.C. 2002. Dynamics of a soil microbial community under spring wheat. Soil Sci. Society America J. 66: 826-833.

Prasad, P.S. and Saifulla, M. 2012. Effect of soil moisture and temperature on population dynamics of *Fusarium udum* causing pigeonpea wilt. Trends in Biosciences 5: 303-305.

Reddy, M.V., Raju, T.N., Sharma, S.B., Nene, Y.L. and McDonald, D.1993. Handbook of Pigeonpea Diseases. Patancheru, Andhra Pradesh, India: ICRISAT. p. 64.

Saremi, H. and Burgess, L.W. 2010. Effect of soil temperature on distribution and population dynamics of Fusarium Species. Agr. Sci. Tech. 2: 119-125.

Watterson, J.C. 1986. Diseases, the tomato crops. Edited by Atherton and Rudich. Champan and Hall Ltd. NY. pp 461-462.

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STUDY OF GENETIC PARAMETERS AND PHOMOPSIS BLIGHT RESISTANCE OF SOME F_6 EGGPLANT LINES

M. I. Khalil[1], M. B. Meah[2] and M. M. Islam[3]

Abstract

The F_6 lines of eggplant derived by crossing the phomopsis blight resistant variety BAU Begun-1 with the susceptible but popular varieties Dohazari G and Laffa S separately were used to select high yielding disease resistant lines and study of genetic parameters. Three parents and seven lines were inoculated with *Phomopsis vexans* under confined field conditions. The inoculated plants exhibited differential disease reactions. Among the parents, BAU Begun-1 was resistant whereas Dohazari G and Laffa S were susceptible to *P. vexans*. All the F_6 lines showed resistant reaction to the disease. Significant differences were observed among the lines in all the yield components studied. High genotypic and phenotypic coefficient of variations, heritability in broad sense and per cent genetic advance were recorded for number of fruits per plant, number of secondary branches per plant, fruit length and fruit breadth. Significant positive correlation was observed between yield contributing characters. The selected lines may be used in future breeding program or eventually to be released as a variety for commercial cultivation after necessary trials.

Key words: Eggplant, phomopsis blight, resistance, genetic parameters.

Introduction

Eggplant also known as Brinjal (*Solanum melongena* L.) is a common fruit vegetable and widely grown in Asia, Africa, and the subtropics, including the southern USA and the Mediterranean region. Asia has the largest eggplant production which comprises more than 87% of the world production (Choudhary and Gaur, 2009). It is the second most important vegetable crop next to potato in Bangladesh in respect of total acreage. In Bangladesh, eggplant cultivated in a total of 46,851 hectare area and annual production is about 429 thousand metric tons (BBS, 2015). This popular vegetable crop is known to suffer from 12 diseases in Bangladesh (Meah *et al.*, 2002), among them Phomopsis blight and fruit rot caused by *Phomopsis vexans.* Harter is very devastating and widespread (Meah *et al.*, 2002). Different studies showed that about 21% of fruit rot and 7% of seed rot in eggplant is caused by *P. vexans* and gives final yield losses of 15-50% (Das, 1998). Farmers have been using a lot of expensive pesticides to control the disease, but no satisfactory results could be obtained. Rather, repeated use of pesticides creates environmental pollution and a health

[1]Plant Pathology Division, Bangladesh Institute of Nuclear Agriculture, Mymensingh-2202, Bangladesh
[2]Department of Plant Pathology, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh
[3]Plant Breeding Division, Bangladesh Institute of Nuclear Agriculture, Mymensingh-2202, Bangladesh

hazard. Host plant resistance is the best control method for environmental and financial reasons. Integrated Pest Management (IPM) Lab of the Bangladesh Agricultural University (BAU) released a Phomopsis blight resistant cultivar as BAU Begun-1 which is popular in north-western region of Bangladesh (Meah, 2009).

The genetic variability, heritability and genetic advance in eggplant genotypes were studied by different scientists (Vadivel and Bapu, 1989; Rai *et al.*, 1998; Sharmin *et al.*, 2010). Resistance to *P. vexans* is recessive and governed by polygenes. Dominance gene effects are more pronounced than additive ones in most of the crosses. Breeding methods for incorporation of resistance into susceptible but commercially adapted cultivars are suggested by Kalda *et al.* (1977), they observed such instances in case of crosses between highly resistant and highly susceptible parents. Many screening experiments were conducted with commercial cultivars as well as offspring's obtained from different crosses. The extensive variability in growth habit, spiny or non-spiny nature, foliage shape/colour, floral structure, fruit shape/size/colour and yields of eggplant were observed to have influence on phomopsis disease reaction (Singh *et al.*, 1999). Therefore, the present research work was undertaken to evaluate F_6 eggplant lines of inter-varietal crossing between BAU Begun-1 and cultivated varieties against phomopsis blight.

Materials and Methods

The experiment was conducted in the field of Department of Plant Pathology, Bangladesh Agricultural University (BAU), Mymensingh during winter season of 2010-11. The seeds of the varieties Dohazari G, Laffa S and BAU Begun-1 and F_6 lines of the intervarietal crosses of eggplant, viz. (1) Dohazari G x BAU Begun-1, (2) Laffa S x BAU Begun-1 were collected from IPM Laboratory, Department of Plant Pathology, BAU. The experiment was laid out in a Randomized Complete Block Design with four replications. The unit plot size was 3.0 m x 2.0 m with 2 rows in each plot. Manure and fertilizers, cow dung (10 t ha^{-1}), urea (130 kg ha^{-1}), TSP (125 kg ha^{-1}), MoP (100 kg ha^{-1}) and mustard oilcake (500 kg ha^{-1}) were applied in the field (Anonymous, 2005). All the decomposed cow dung, TSP and half the amount of MoP were applied during land preparation. Urea and the remaining half of MoP were applied in three installments as top dressing. Proper shading and watering were continued till the seedlings were established. Weeding, irrigation and other intercultural operations were done whenever necessary.

A mixture of cultures of five isolates of *P. vexans* was used for inoculation. The isolates of *P. vexans* were collected from IPM Lab., BAU. The multiplication of *P. vexans* and preparation of spore suspension were done according to the procedure of Islam (2006). All the plants of F_6 generations and parents were inoculated at the flowering and fruiting stages. Spore suspension (5×10^6 spores ml^{-1}) was sprayed @ 70 ml per plant (Islam, 2006). The spraying was done at afternoon and inoculated plants were covered with transparent polythene bag for 48 hours for making favorable condition of infection. After inoculation, symptoms on leaves, flowers and fruits were observed at seven-day interval up to 21 days.

Data on leaf infection (%), leaf area diseased (% LAD), flower infection (%), fruit infection (%) and fruit area diseased (% FAD) were recorded. Visual symptoms of the percentage of LAD and FAD were done where the area of a single leaf or fruit as 100% was considered. The LAD or FAD was then calculated considering the total number of leaves or fruits investigated. The disease severity was recorded according to the standard rating scale (1-5) used by Islam (1990). The percent disease index (PDI) was calculated according to the formula of Singh (1984). The characters responsible for yield of eggplant were studied and data were recorded from all the plants. Plant height, number of primary branches per plant, number of secondary branches per plant, number of fruits per plant, fruit length, fruit breadth and individual fruit weight were recorded in the field before harvest. The mature fruits were harvested at the edible stage at an interval of seven days. Five fruits per variety/genotype were allowed to ripe and seeds were collected from them for growing plants in the next year.

Data analysis

Data were analyzed to find out the statistical significance. Analysis of variances followed by Duncan's Multiple Range Test was performed to test the differences between the genotypes with the computer based software MSTATC version 2.3 (Russel, 1986). Besides, different components of genotypic and phenotypic variances, heritability, genetic advance and correlation were also estimated. Genotypic and phenotypic variances and heritability in broad sense were estimated according to formula given by Johnson *et al.* (1955). Genotypic and phenotypic coefficients of variation were estimated according to the formula used by Burton (1952). The expected genetic advance (GA) for different characters under investigation was estimated according to the formula used by Johnson *et al.* (1955) and Allard (1960). Genetic advance in percentage of mean was calculated by the formula used by Comstock and Robinson (1952). Using the formula of Singh and Chaudhary (1985), genotypic and phenotypic covariances were calculated. Genotypic and phenotypic correlation coefficients between different characters in all possible combinations were calculated with the formula given by Miller *et al.* (1958).

Results and Discussion

Reaction of the F_6 lines to Phomopsis vexans

F_6 eggplants and respective parents showed different percentages of leaf infection and severity (leaf area diseased) after inoculated with *P. vexans* (Table 1). Among the seven F_6 crosses and their respective parents, the highest (35.42%) leaf infection was found in cultivar Dohazari G followed by Laffa S (32.75%). The eggplant cultivar BAU Begun-1 did not produce any infection on leaf. In contrast, the F_6 progenies (Dohazari GxBAU Begun-1) and (Laffa S x BAU Begun-1) showed leaf infections of 2.43 to 2.47% and 2.27 to 2.32%, respectively. Similarly the Percent Disease Index (PDI) was recorded the highest in the cultivars Dohazari G and Laffa S. Less than 1% PDI was recorded for all the F_6 progenies of eggplant. The fruit infection of the tested lines ranged from 0.0 to 27.96%. The highest percentage of fruit infection was recorded in parent cultivar Laffa S followed by Dohazari G (Table 1). There was no fruit infection observed in the cultivar BAU Begun-1. All the F_6 progenies of eggplants (Laffa SxBAU Begun-1) and (Dohazari GxBAU Begun-1) produced fruit infection less than 2% which were statistically similar. The per cent disease index was also the highest in Dohazari G (31.92) followed by Laffa S (29.88). But all the F_6 progenies have less than one per cent PDI, whereas BAU Begun-1 found free from disease.

Table 1. Reaction of F_6 eggplant lines along with their parents against induced *P. vexans* during 2010-11 at Mymensingh

Lines/cultivars	Infected leaves (%)	Per cent disease index (leaf)	Infected fruits (%)	Per cent disease index (fruit)	Reaction
Dohazari G x BAU Begun-1					
Green round	2.43 c	0.27 b	1.35 bc	0.36 c	Resistant
Green globose	2.44 c	0.39 b	1.81 b	0.39 c	Resistant
Green long	2.47 c	0.41 b	1.85 b	0.34 c	Resistant
Laffa S x BAU Begun-1					
Green globose	2.31 c	0.29 b	1.28 bc	0.37 c	Resistant
Green white long	2.32 c	0.34 b	1.52 b	0.31 c	Resistant
Purple globose	2.27 c	0.41 b	1.64 b	0.33 c	Resistant
Purple long	2.33 c	0.30 b	1.71 b	0.40 c	Resistant
BAU Begun-1 (parent)	0.00 d	0.00 b	0.00 c	0.00 c	Resistant
Dohazari G (parent)	35.42 a	33.12 a	26.97 a	31.92 a	Susceptible
Laffa S (parent)	32.75 b	32.66 a	27.96 a	29.88 b	Susceptible

Means followed by the same letter in a column did not differ significantly at 1% level according to DMRT

The tested lines were categorized according to severity and found parent cultivars Dohazari G and Laffa S as susceptible to *Phomopsis vexans* and cultivar BAU Begun-1 was resistant. All the F_6 plants were grouped based on colour and shape and graded as resistant though a few plants showed infection (PDI less than 1%). Fruit shape and colour had no effect on the intensity of infection (Table 1). Among the F_1, F_2, F_3 and F_5 populations screen against *P. vexans* by different authors found few plants infected with phomopsis blight and fruit rot (Meah *et al.*, 2002 and Sharmin *et al.*, 2010). They also reported Laffa S and Dohazari G as susceptible and BAU Begun-1 as resistant against *P. vexans.*

Performance of the lines

All the yield contributing characters had significant differences amongst the F_6 lines (Table 2). This means differences exist between the tested lines even within the same environment where they were grown. Plant height ranged from 58.15 to 72.08 cm. Laffa S was the tallest cultivar although did not differ significantly with Dohazari G (Table 2). In contrast, green white long line of Laffa S x BAU Begun-1 was the shortest which was statistically identical with other lines. This finding is in agreement with Mishra *et al.* (1990) and Singh and Singh (1994) who observed significant differences in plant height of 25 brinjal lines.

Table 2. Performance of infected phomopsis blight and fruit rot F_6 eggplant lines along with parents for yield contributing characters during 2010-11

Lines/cultivars	Plant height (cm)	Primary branch plant^{-1}	Secondary branch plant^{-1}	Fruits plant^{-1}	Fruit length (cm)	Fruit width (cm)
Dohazari G x BAU Begun-1						
Green round	59.29 b	14.00 ab	12.05 d	11.27 d	10.92 c	7.79 bcd
Green globose	61.74 b	11.93 c	13.09 cd	13.16 c	12.51 b	7.15 cde
Green long	60.70 b	12.75 bc	12.83 cd	14.19 c	16.98 a	7.70 bcd
Laffa S x BAU Begun-1						
Green globose	62.13 b	14.39 a	13.21 cd	13.21 c	11.23 bc	7.84 bc
Green white long	58.15 b	13.08 abc	14.13 bc	12.82 c	15.68 bc	6.98 de
Purple globose	60.50 b	12.29 c	12.51 d	13.43 c	12.23 bc	7.53 b-e
Purple long	61.74 b	12.70 bc	12.11 d	13.60 c	15.68 a	6.85 e
BAU Begun-1(parent)	62.64 b	14.34 a	15.96 a	16.06 b	11.23 bc	9.19 a
Dohazari G (parent)	70.38 a	13.47 abc	15.13 ab	19.71 a	15.72 a	8.29 b
Laffa S (parent)	72.08 a	14.24 ab	15.63 a	19.08 a	16.79 a	7.16 cde

Means followed by the same letter in a column did not differ significantly at 1% level according to DMRT

Number of primary branches per plant ranged from 11.93 to 14.39. Green globose progeny of Laffa S x BAU Begun-1 produced maximum number of primary branches per plant followed by BAU Begun-1 (14.34). Green globose line of Dohazari G x BAU Begun-1 produced the lowest number of primary branches and it was statistically similar with most of the lines. Singh and Singh (1994) also reported significant differences of primary branches in brinjal. The highest number (15.96) of secondary branches was recorded in BAU Begun-1 and it was statistically similar with other two parents. The lowest number of secondary branches (12.05) was found in green round progeny of Dohazari G x BAU Begun-1. Vadivel and Bapu (1989) observed wide variation in number of secondary branches per plant in F_2 and F_3 generations of eggplant. Number of fruits per plant ranged from 11.27 to 19.71. The parent Dohazari G produced the highest number of fruits followed by Laffa S and BAU Begun-1. Almost all the F_6 lines were produced statistically similar number of fruits. This is fully agreement with the result of Singh and Singh (1994), Rai *et al.* (1998) and Sharmin *et al.* (2010). Fruit length varied from 10.92 to 16.98 cm. The highest fruit length was recorded in green long line of F_6 (Dohazari G x BAU Begun-1). In contrast, the lowest fruit length was observed in the green round line of F_6 (Dohazari GxBAU Begun-1). Fruit width was recorded as 6.85 to 9.19 cm. The highest fruit width was observed in BAU Begun-1 followed by Dohazari G. The lowest fruit diameter found in purple long line (Laffa S x BAU Begun-1). Mishra *et al.* (1990) and Singh and Singh (1994) also reported wide range of variability in fruit length and width in their study with brinjal germplasms.

Individual fruit weight ranged from 238.53 to 296.50 g. The highest individual fruit weight was found in BAU Begun-1 followed by Laffa S and Dohazari G (Fig. 1). The lowest individual fruit weight was observed in green round of F_6 line (Dohazari G x BAU Begun-1). Similar findings also observed by Sharmin *et al.* (2010).

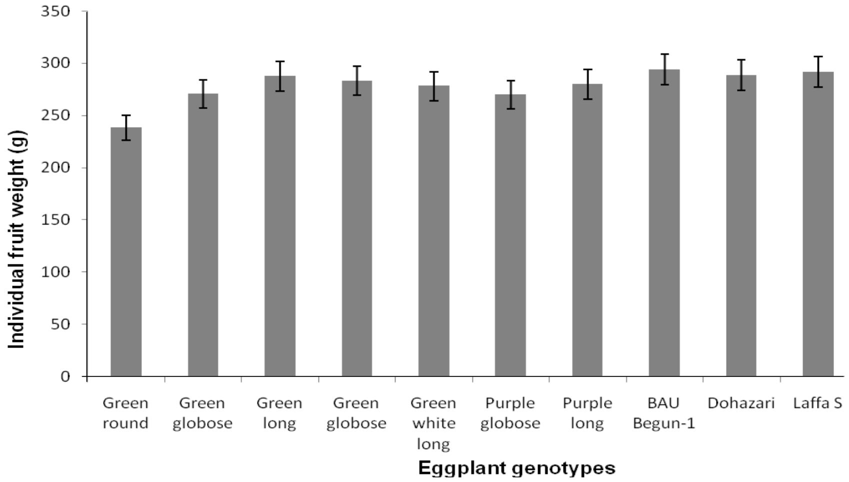

Fig. 1. Individual fruit weight of F_6 eggplant lines and their parents as affected by phomopsis blight and fruit rot. Vertical bars represents SE(±)

Variability, heritability and genetic advance for yield contributing characters

Different genetic parameters i.e. genotypic and phenotypic variances, genotypic and phenotypic coefficient of variations, heritability and genetic advance in eggplant cultivars and their F_6 progenies were studied for the yield contributing characters (Table 3). The highest genotypic (δ^2g) and phenotypic (δ^2p) variances were found in individual fruit weight (227.05 and 367.72) followed by plant height (19.65 and 25.36), number of fruits per plant (7.54 and 8.08) and fruit length (6.40 and 6.89). In contrast, the lowest δ^2g and δ^2p were observed in number of secondary branches per plant, number of primary branches per plant and fruit width. The genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) ranged from 5.42 to 18.74 and 6.69 to 19.40, respectively. The highest genotypic coefficient of variation and phenotypic coefficient of variation were found in number of fruits plant followed by fruit length. On the other hand, the lowest GCV and PCV were calculated for individual fruit weight. Similar findings also reported by Sharmin *et al.* (2010). Heritability of different yield attributes of the F_6 lines ranged from 56.67 to 93.32%. The highest heritability was calculated for number of fruits per plant followed by fruit length (92.89%). The lowest heritability was recorded for number of primary branch per plant.

The genetic advance and genetic advance in percentage of mean varied from 1.22 to 24.39 and 8.80 to 35.27, respectively. The highest genetic advance was recorded for individual fruit weight, whereas genetic advance in percentage of mean was found in fruit length. The lowest genetic advance and percentage of genetic advance in percentage of mean were recorded for fruit width and individual fruit weight. This finding is in line of results reported by Rai *et al.* (1998).

Table 3. Estimation of genetic parameters for yield contributing characters in seven F_6 eggplant lines along with their parents

Characters	Genotypic variance (σ^2 g)	Phenotypic variance (σ^2p)	Genotypic coefficient of variation (%)	Phenotypic coefficient of variation (%)	Heritability in board sense (%)	Genetic advance (%)
Plant height (cm)	19.65	25.36	7.04	8.01	77.48	12.43
Primary branches plant^{-1}	0.68	1.20	6.19	8.22	56.67	10.04
Secondary branches plant^{-1} (no.)	1.98	2.52	10.30	11.62	78.57	18.76
Fruits plant^{-1} (no.)	7.54	8.08	18.74	19.40	93.32	37.71
Fruit length (cm)	6.40	6.89	18.13	18.82	92.89	35.27
Fruit width (cm)	0.46	0.60	8.87	10.13	76.67	15.93
Individual fruit weight (g)	227.05	367.72	5.42	6.89	61.75	8.80

Relationship between different yield contributing characters

Plant height was positively and not significantly correlated with number of primary branch per plant, number of secondary branches per plant, fruits per plant, fruit length, fruit width and individual fruit weight (Table 4). Plant height was not significant with number of primary branches per plant and fruits per plant. This finding supports the result of Mishra *et al.* (1990) and Sharmin *et al.* (2010). The relationship of number of primary branches per plant with number of secondary branches per plant, number of fruits per plant, fruit width and individual fruit weight were positive. The negative, non-significant correlation was observed for fruit length. Sharmin *et al.* (2010) reported similar results. Number of secondary branches per plant was positively and significantly correlated with fruits per plant and individual fruit weight, but insignificant correlation was found with fruit length and fruit width. The relationships of number of fruits per plant with fruit length and fruit width were positive and significant where as not significant with individual fruit weight. Fruit length had negative correlation with fruit width, but positive with individual fruit weight.

Table 4. Correlation coefficients between different yield contributing characters in cultivars and their F_6 eggplant lines along with their parents

Characters	No. of primary branches plant^{-1}	No. of secondary branches plant^{-1}	No. of fruits plant^{-1}	Fruit length (cm)	Fruit width (cm)	Individual fruit weight (g)
Plant height (cm)	0.356	0.656*	0.935***	0.390	0.140	0.512
No. of primary branches plant^{-1}		0.517	0.318	- 0.234	0.520	0.165
No. of secondary branches plant^{-1}			0.796**	0.154	0.487	0.675*
Number of fruits plant^{-1}				0.453	0.307	0.685*
Fruit length (cm)					- 0.470	0.473
Fruit width (cm)						0.231
Individual fruit weight (g)						

*, ** and *** indicate significant at 5%, 1% and 0.1% level of probability, respectively.

The relationship of fruit width with individual fruit weight was positive and not significant. Individual fruit weight was positively and significantly correlated with number of secondary branches per plant and number of fruits per plant. But positive and notsignificant relationships were observed with plant height, number of primary branches per plant, fruit length and fruit width. Positive correlation of fruit with number of fruit, fruit length and fruit width were also reported by Sharmin *et al.* (2010).

Conclusion

Some eggplant lines showed resistant reaction to phomopsis blight and produce better yield than parents. Selected lines may be used in future breeding program or eventually to be released as a variety for commercial cultivation after necessary trials.

References

Allard, R.W. 1960. Principles of Plant Breeding. John Willey and Sons. Inc. New York. p. 36.

Anonymous. 2005. Fertilizer Recommendation Guide. Bangladesh Agricultural Research Council (BARC). Farmgate, Dhaka. p. 98.

BBS (Bangladesh Bureau of Statistics). 2015. Statistical Yearbook of Bangladesh. Bangladesh Bureau of Statistics. Ministry of Planning, Government of the Peoples' republic of Bangladesh. p. 248.

Burton, G.M. 1952. Quantitative inheritance in grasses. Proc. 6th Int. Grassland Cong. 1: 277-283.

Choudhary, B. and Gaur, K. 2009. The development and regulation of Bt brinjal in India (Eggplant/Aubergine). International Service for the Acquisition of Agri-biotech Applications (ISAAA) Brief No. 38. ISAAA, Ithaca, NY, USA. p. 15.

Comstock, R.E. and Robinson, H.F. 1952. Genetic parameters, their estimation and significance. Proc. 6th International Congress, 1: 284-291.

Das, B.H. 1998. Studies on Phomopsis fruit rot of brinjal. M.S. thesis. Department of Plant Pathology. Bangladesh Agricultural University, Mymensingh. p. 64.

Islam, M.R. 2006. An integrated approach for management of Phomopsis blight and fruit rot of eggplant. Ph.D. thesis. Department of Plant Pathology, Bangladesh Agricultural University, Mymensingh. p. 133.

Johnson, H.W., Robinson, H.F. and Comstock, R.E. 1955. Estimation of genetic and environmental variability in Soybean. Agron. J. 47: 314-318.

Kalda, T.S., Swarup, V.and Choudhury, B. 1977. Resistance to Phomopsis blight in eggplant. Veg. Sci. 4: 90-101.

Meah, M.B. 2009. Formulation of Biopesticides in controlling Phomopsis of eggplant. Annual research report (2008-2009). Dept. of Plant Pathology, Bangladesh Agricultural University, Mymensingh, Bangladesh. pp. 43-44.

Meah, M.B., Hossain, M.D. and Islam, M.R. 2002. Development of an integrated approach for management of Phomopsis blight and fruit rot of eggplant in Bangladesh. Annual research report (2001-2002). Dept. of Plant Pathology, Bangladesh Agricultural University, Mymensingh, Bangladesh. pp. 8-10.

Miller, P.A., Williams, J.C., Robinson, H.F. and Comstock, R.E. 1958. Estimates of genetic and environmental variance and covariance and their implication in selection. Agron. J. 50: 126-131.

Mishra, S.N., Sahoo, S.C. and Mishra, R.S. 1990. Variability, heritability and genetic advance in brinjal (*Solanum melongena* L.). Environ. Ecol. 8: 162-163.

Rai, N., Singh, A.K. and Sarnaik, D.A. 1998. Estimation of variability, heritability and scope of improvement for yield components in brinjal (*Solanum melongena* L.). Agril. Sci. Digwest Karnal, 18: 187-190.

Russel, DF. 1986. MSTAT-C, MSTAT Director, Crop and Soil Sci, Dept., Michigan State Univ., USA.

Sharmin, D., Meah, M.B. and Moniruzzaman, M. 2010. Inheritance of resistance to phomopsis blight and fruit rot in brinjal. J. Agrofor. Environ. 3(2): 135-140.

Singh, N., Gyanendra, S. and Kalda, T.S. 1999. Genetic diversity in eggplant. IPGRI-Newsletter for Asia, the Pacific and Oceana. 29: 22-28.

Singh, P.K. and Chaudhary, B.D. 1985. Biometrical Methods in Quantitative Genetic Analysis. Kalyani Publishers, New Delhi, India. p. 318.

Singh, R.S. 1984. An Introduction to Principles of Plant Pathology. 2nd edn. IBH Publishing Co. Delhi, India. p. 608.

Singh, V.K. and Singh, S.N. 1994. Genetic variability in brinjal (*Solanum melongena* L.). J. Appl. Biol. 4: 16-18.

Vadivel, E. and Bapu, J.P.K. 1989. Studies on genetic variability and heritability estimates in F_2 and F_3 generations in eggplant (*Solanum melongena* L.). South Indian Hort., 37: 75-76.

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VARIATION IN MORPHO-PHYSIOLOGICAL FEATURES AND YIELD OF SIX FINE GRAIN AROMATIC RICE

M. M. A. Mondal

Abstract

An experiment was conducted at the field laboratory of Bangladesh Institute of Nuclear Agriculture, Mymensingh, during Aman season (July to December) with five promising mutants of fine grain rice *viz*., RM 100-1, RM 100-16, RM 100-18, RM 100-24 and RM 150-10 along with their mother, Ukunimadhu to evaluate their some morpho-physiological features and their contribution on grain yield. Results revealed that high yielding mutants, in general, showed superiority in morpho-physiological characters like root volume, leaf area, total dry mass production, absolute growth rate, relative growth rate, chlorophyll and soluble protein content in leaves and harvest index than the low yielding ones. The mutant, RM 100-24 showed superiority in growth, biochemical parameters and dry matter partitioning to economic yield which resulted higher number of tillers hill^{-1} and grains panicle^{-1}, thereby grain yield. In contrast, RM 150-10 showed inferiority in morpho-physiological characters and performed the lowest yield attributes and grain yield. This information may be useful in future plant breeding programme.

Key word: Growth, chlorophyll, harvest index, yield, fine grain rice.

Introduction

In Bangladesh, rice (*Oryza sativa* L.) is grown in about 80.5% of the arable land, of which aromatic rice varieties have occupied about 12.5% of the total *Aman* rice cultivation (BBS, 2015). The principal constraint of fine grain aromatic rice production is its low yield potential because of undesirable plant type for tall stature, long and droopy leaves, weak culms, which causes lodging thereby a great reduction in grain yield. On the other hand, modern varieties possess short and stout culms with dark green, thick leaves and do not lodge. Little is known about the morpho-physiological characteristics in South Asia to explain the causes of low yield of fine grain aromatic rice. Important physiological attributes such as LAI, CGR, NAR and photo-assimilate production capacity and its efficient partitioning to economic yield etc can address various constraints of a variety for increasing its productivity (Mondal *et al*., 2011). It is suggested that high partitioning efficiency (harvest index) would be advantageous for high yield (Puteh *et al*., 2014). A plant with optimum LAI and NAR may produce higher biological yield (Mondal *et al*., 2012). Ashrafuzzaman *et al*. (2009) characterized local rice cultivars both on morphology and their physico-chemical qualities and pointed out some physiological limitations that should be

Crop Physiology Divison, Bangladesh Institute of Nuclear Agriculture, Mymensingh-2202, Bangladesh.

improved for the improvement of those cultivars. Sharma and Haloi (2001) characterized some local scented rice on the basis of their physiological assimilate partitioning behaviour. They pointed out that the improvement of partitioning efficiency is one of the best criteria for improvement of scented rice.

Varietal improvement of rice is essentially needed to increase grain yield by creating variability in the available germplasm followed by appropriate selection procedures. The induced mutation breeding is an effective technique for creating substantial genetic variability in plant species. The mutation breeding can play an efficient role in developing an ideal plant type having superior physiological performance as well as high yield (Dutta, 2001). To increase productivity in aromatic rice, it is therefore necessary to create variability and select desirable type with stable yield.

Under these circumstances, the scientists of BINA have developed several promising mutants of aromatic rice with high yield potentials using Ukunimadhu as mother by γ-irradiation. These mutants need to be assessed for their morphological and physiological maneuvering that takes place compared to the existing rice cultivars. The present research work has been designed to study different morpho-physiological parameters of some fine grain rice mutants developed at BINA. Therefore, the present study was undertaken to assess the performance of five promising aromatic rice mutants along with the mother variety, Ukunimadhu on the basis of morphological, physiological and yield attributes; and to suggest plant breeder by generating information through physiological study for fixing breeding strategy.

Materials and Methods

The experiment was carried out at the Field Laboratory, Bangladesh Institute of Nuclear Agriculture, Mymensingh during the period from July to December 2011. The treatment of this experiment consisted of five promising mutants of fine grain aromatic rice *viz.* RM 100-1, RM 100-16, RM 100-18, RM 100-24, RM 150-10 and mother Ukunimadhu. The experiment was laid out in a Randomized Complete Block design with three replications. The size of the unit plot was 3.0m × 3.0m. Urea, triple super phosphate (TSP), muriate of potash (MP) and gypsum were used as sources of nitrogen, phosphorus, potassium and sulphur, respectively. The dose of fertilizers was: urea 60, TSP 65, MP 135 and gypsum 45 kg ha^{-1} (BARC, 2005). Total amount of TSP, MP and gypsum, and 33% of urea were applied at basal doses during final land preparation. The remaining 66% urea was top dressed in two equal splits at 18 and 45 days after transplanting. Thirty day-old seedlings were transplanted on 01 August 2011 with 2 seedlings per hill maintaining spacing of 20 cm × 15 cm. Gap filling was done within a week of transplanting. Two hand weeding were done at 25 and 50 DAT. Pesticides were used to control leaf hopper. Other intercultural operations were done as and when necessitated. To study ontogenetic growth characteristics, a total of three harvests were made at 30, 50 and 70 DAT. From each sampling, five hills were randomly selected from each plot and uprooted for collecting necessary parameters. The plants were separated into leaves, stems and roots and the corresponding dry weight were recorded after oven drying at 80 ± 2 ^{0}C for 72 hours. The leaf area of each sample was measured by LICOR automatic leaf area meter (Model: LICOR 3000 USA). The growth analyses like CGR, NAR and RGR were carried out following the formulae of Hunt (1978). Root volume was measured by water displacement method in a 1000 ml measuring cylinder. The freshly washed roots were carefully dried with soft tissue papers and immediately immersed in a graduated measuring cylinder. The direct increase in volume was considered as the volume of the roots. Leaf Chlorophyll was determined at 50, 70 and 90 DAT following the method of Yoshida *et al*. (1976). Total sugar was determined at 50, 65, 80 and 100 DAT following the method of Dubois *et al*. (1956). Soluble protein was determined at 50, 65, 80 and 100 DAT following the method of Lowry *et al*. (1951). At harvest, the morphological and yield attributes were recorded from ten sample hills of each plot. The grain and straw yield were collected from whole plots and converted into t ha^{-1}. Harvest index (HI) was calculated by dividing economic yield to biological yield of plant by multiplying with 100 and expressed in percentage. The collected data were analyzed statistically following the analysis of variance technique and the mean differences were adjudged with Duncan's Multiple Range Test using the statistical computer package program, MSTAT (Russell, 1986).

Results and Discussion

Growth parameters: There were significant differences in plant height and number of tillers hill^{-1} among the mutants/variety at all growth stages (Fig. 1). The number of tillers hill^{-1} increased till 70 DAT followed by slightly decline whereas plant height increased with age. At later growth stage, the highest plant height (155.9 cm) was recorded in RM 100-16, which was not significantly different from other four genotypes *viz*. RM 100-18, RM 100-24, RM 150-10 and Ukunimadhu. On the other hand, RM 100-1 maintained shorter plant height in most of the growth stages. The shorter plant height in RM 100-1 due to shorter internode length (Table 2). The mutant RM 100-24, the high yielding genotype, always maintained higher number of tillers hill^{-1} over its growth period followed by RM 100-18. In contrast, RM 100-1, the low yielding genotype produced the fewer number of tillers hill^{-1} at most of the growth stages. Tiller is a unique character to rice for production. With decreasing tillers hill^{-1}, yield will be decreased considerably (Mondal *et al*, 2012). This type of result was also observed in the present study. Further many researchers reported that grain yield positively correlated with effective tillers hill^{-1} that supported the present results. Prasad *et al.* (2001) also found significant differences in plant height and number of tillers hill^{-1} in 113 fine grain rice genotypes.

The effect of mutants/variety on stem weight and leaf area development at three growth stages was significant (Fig. 1). Result showed that stem dry weight and leaf area increased progressively with increased plant age. Result revealed that dry matter accumulation in stem was slow till 50 DAT and thereafter increased rapidly. AT 70 DAT, Ukunimadhu showed the highest stem dry weight (53.9 g hill^{-1}) followed by RM 100-24

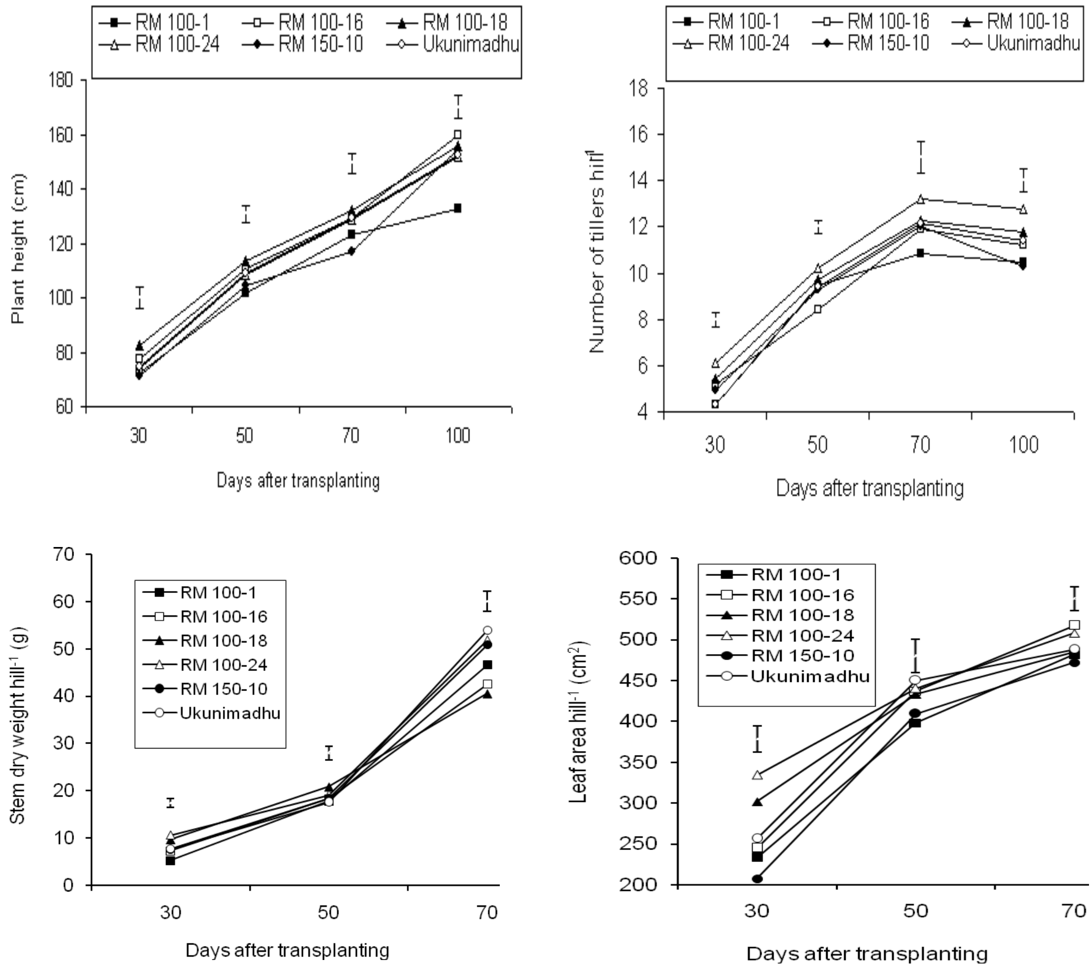

Fig. 1. Changes in plant height and number of tillers hill^{-1} in five aromatic riceMutants along with mother at different growth stages. Vertical bars represent LSD $_{(0.05)}$.

(51.9 g hill^{-1}) and RM 150-10 (50.8 g hill^{-1}). On the other hand, RM 100-18 showed the lowest stem dry matter (40.5 g hill^{-1}) which is identical to RM 100-16 (42.5 g hill^{-1}). Increased stem dry matter in Ukunimadhu and RM 100-24 was possibly due to greater leaf area hill^{-1} (Fig. 1). The result is supported by the result of Mondal *et al.* (2013) who reported that TDM increased with increasing plant age up to physiological maturity and high yield genotypes always maintained higher TDM hill^{-1}. On the other hand, at later growth stage, the higher leaf area was recorded in RM 100-16 and RM 100-24. In contrast, RM 150-10 and RM 100-1 produced the lowest leaf area hill^{-1} at all growth stages. The variation in leaf area might occur due to the variation in number of leaves and their expansion. The result obtained from the present study is consistent with result of Sharma and Haloi (2001), who stated that variation in leaf area could be attributed to the changes in number of leaves in scented rice.

The effect of fine grain rice mutants/variety on root volume and root dry weight hill^{-1} at 30, 50 and 70 days after transplanting (DAT) was significant (Table 1). Result revealed that root volume and root dry weight hill^{-1} increased with age till 70 DAT. This might be due to increase in root numbers. The highest root volume and root dry weight hill^{-1} at all growth stages was recorded in RM 100-24 followed by RM 100-18. In contrast, RM 150-10 always maintained the lowest root volume and root dry weight hill^{-1} at all growth stages. The result obtained from the present study is consistent with result of Mondal *et al.* (2013) in rice, who observed that variation in root volume among genotypes of rice.

Table 1. Changes in root volume and root dry weight in five aromatic rice genotypes along with mother at different growth stages

Mutants/variety	Root volume hill^{-1} (cc)			Root dry weight hill^{-1} (g)		
	30 DAT	50 DAT	70 DAT	30 DAT	50 DAT	70 DAT
RM 100-1	539.3 ab	733.3 ab	841.7 ab	3.61 d	6.25 d	10.69 c
RM 100-16	553.3 ab	726.7 ab	850.0 a	4.39 c	7.59 bc	11.80 b
RM 100-18	546.7 ab	733.3 ab	830.0 ab	4.91 abc	6.96 cd	11.57 b
RM 100-24	558 a	740.0 a	853.3 a	5.44 a	8.49 a	12.67 a
RM 150-10	520.3 b	623.3 b	800.0 b	4.63 bc	7.71 abc	8.71 d
Ukunmodhu (mother)	550.3 ab	733.3 ab	833.3 ab	5.12 ab	8.05 ab	10.71 c
F-test	NS	*	*	**	**	**
CV (%)	3.59	7.01	3.36	6.22	7.45	4.01

In a column figures with common letter (s) do not differ significantly at $P \leq 0.05$ as per DMRT;
NS= not significant; * and ** indicate significant at 5% and 1% levels of probability, respectively.

The crop growth rate (CGR), relative growth rate (RGR) and net assimilation rate (NAR) derived from six genotypes was determined from 30 DAT to 70 DAT and the results presented in Table 2. Results revealed that CGR, RGR and NAR in all genotypes were significantly different at all growth stages. Results revealed that CGR increased with age until 70 DAT while reverse trend was observed in case of RGR and NAR. The mutant RM 100-24, the high yielding genotype always maintained the highest CGR and RGR value over the growth period. In contrast, at 30-50 DAT, the lowest CGR was observed in RM 150-10 (1.03 g hill^{-1} d^{-1}) whereas at 50-70 DAT the lowest CGR was recorded in RM 100-18 (1.10 g hill^{-1} d^{-1}). Ukunimadhu showed the inferiority in RGR and NAR at all growth stages. At 30-50 DAT, the highest NAR (5.43 mg cm^{-2} d^{-1}) was observed in RM 100-16 and the lowest (3.62 mg cm^{-2} d^{-1}) was observed in RM 150-10. AT 50-70 DAT, the highest NAR (4.45 mg cm^{-2} d^{-1}) was recorded in RM 100-1 whilst the lowest was recorded in RM 100-18 (3.05 mg cm^{-2} d^{-1}). In contrast, RM 150-10 showed inferiority in NAR at most of the growth stages. CGR is positively correlated with LAI (Malek *et al*., 2012). The CGR increased along with increase in LAI. The lower value of CGR at initial stages of growth was due to lower LAI. This result is in agreement with the findings of Mondal *et al*. (2011). At 50-70 DAT, the CGR value was found to be maximum which means that plants utilized assimilate for the growth of leaf area. These results are consistent with the results of Shahidullah *et al.* (2010). They reported that varietal differences of CGR were significant at different growth stages and high yielding genotypes maintained higher CGR than low yielding ones.

Table 2. Changes in crop growth rate, relative growth rate and net assimilation rate in five aromatic rice genotypes along with mother at two growth stages

Mutants/variety	Absolute growth rate (g hill^{-1} d^{-1})		Relative growth rate (mg g^{-1} d^{-1})		Net assimilation rate (mg cm^{-2} d^{-1})	
	30-50 DAT	50-70 DAT	30-50 DAT	50-70 DAT	30-50 DAT	50-70 DAT
RM 100-1	1.442 b	1.950 b	57.35 a	37.41 b	4.68 bc	4.45 a
RM 100-16	1.80 c	1.980 b	57.57 a	40.00 ab	5.43 a	4.16 b
RM 100-18	1.520 ab	1.400 c	56.40 a	25.46 c	4.16 c	3.05 d
RM 100-24	1.690 a	2.300 a	58.00 a	44.20 a	4.86 b	4.39 a
RM 150-10	1.030 c	2.030 b	49.90 b	42.26 a	3.62 d	3.47 c
Ukunimadhu (mother)	1.160 c	1.970 b	51.50 b	37.12 b	4.17 c	3.37 c
F-test	**	**	**	**	**	**
CV (%)	12.57	10.02	3.81	6.36	4.56	5.55

In a column figures with common letter (s) do not differ significantly at P ≤ 0.05 as per DMRT;
DAT = Days after transplanting; * and ** indicate significant at 5% and 1% levels of probability, respectively.

Morpho-physiological characters and days required to maturity:

The Internode length, panicle length, total dry mass hill^{-1}, harvest index (HI) and days required to maturity differed significantly among the studied rice mutants/cultivar (Table 3). The tallest internode was recorded in RM 100-18 (24.90 cm), which was statistically similar to that of RM 100-16 (24.50 cm). In contrast, the shortest internode was recorded in RM 150-10 (19.36 cm) followed by RM 100-24 (21.22 cm), RM 100-1 (21.41 cm) and Ukunimadhu (21.66 cm). The highest panicle length was observed in RM 100-24 (29.00 cm) followed by Ukunimadhu (28.35 cm) with same statistical rank. The lowest panicle length was observed in RM 100-1 (25.56 cm). The highest biological yield was recorded in RM 100-24 (57.77 g hill^{-1}), which was statistically similar to other three genotypes *viz*. RM 100-1 (55.79 g hill^{-1}), RM 100-16 (53.59 g hill^{-1}) and Ukunimadhu (54.63 g hill^{-1}). In contrast, the lowest biological yield was recorded in RM 100-18 (47.43 g hill^{-1}). Pandey *et al.* (2009) reported that grain yield was positively correlated with biological yield in rice. In the present investigation, the high yielding genotypes also showed higher yield.

Table 3. Morpho-physiological characters and days to maturity of five aromatic rice genotypes along with mother

Mutants/variety	Internode length (cm)	Panicle length (cm)	Total dry mass hill^{-1} (g)	Harvest index (%)	Days to maturity
RM 100-1	21.41 b	25.56 c	55.79 a	42.38 b	137 e
RM 100-16	24.50 a	25.92 c	53.59 ab	44.02 ab	140 d
RM 100-18	24.94 a	26.22 c	47.43 c	45.78 a	145 b
RM 100-24	21.22 b	29.00 a	57.77 a	43.20 ab	140 d
RM 150-10	19.36 b	26.82 bc	48.86 bc	44.40 ab	143 c
Ukunimadhu (mother)	21.66 b	28.35 ab	54.63 a	43.53 ab	149 a
F-test	**	**	**	*	**
CV (%)	5.69	3.34	5.52	3.07	1.98

In a column figures with common letter (s) do not differ significantly at P ≤ 0.05 as per DMRT;
* and ** indicate significant at 5% and 1% levels of probability, respectively.

The highest HI was observed in RM 100-18 (45.78%) which was statistically similar to other four genotypes except RM 100-1. The lowest HI was recorded in RM 100-1 (42.38%). It means dry matter partitioning to economic yield is inferior in RM 100-1 than the other genotypes. HI is a measure of the efficiency of conversion of photosynthate into economic yield of a crop plant (Mondal *et al*., 2014a). According to Mondal *et al.* (2014b) high yield is determined by physiological process leading to a high net accumulation of photosynthates and it's partitioning into plant and seed. This opinion has been reflected in the present study. In the present investigation, high yielding genotypes maintained high HI. Shahidullah *et al.* (2010) also reported that high yielding genotypes maintained efficient dry matter portioning to economic yield.

Results revealed that all the mutants required shorter days to maturity than the mother, Ukunimadhu. Ukunimadhu required the highest days to maturity (149 days). On the other hand, RM 100-1 required the lowest days to maturity (137 days). Other mutants were in intermediate group.

Biochemical parameters:

The variation in chlorophyll, total sugar and soluble protein content in leaves among the mutants/cultivar was assessed from 50 DAT to 100 DAT and presented in Fig. 2. Genotypic differences in chlorophyll, total sugar and soluble protein content in leaf was found significant at all growth stages except 50 DAT for total sugar. It was observed that total sugar and soluble protein content in leaves increased with age till 65 DAT followed by a decline, while an inverse relationship between chlorophyll content in leaf and plant age was existed from 50 DAT. Chlorophyll content showed the highest value at vegetative stage (50 DAT) followed by a decline till grain filling stage (90 DAT). Results further revealed that RM 100-24 showed the highest chlorophyll, total sugar and soluble protein content in leaves at all growth stages. In contrast, the lowest chlorophyll and total sugar content and soluble protein content in leaves at most growth stages was recorded in RM 100-18. Rahman *et al.* (2013) reported that grain yield was positively correlated with chlorophyll content. In the present investigation, high yielding genotypes also showed higher chlorophyll content in rice mutants.

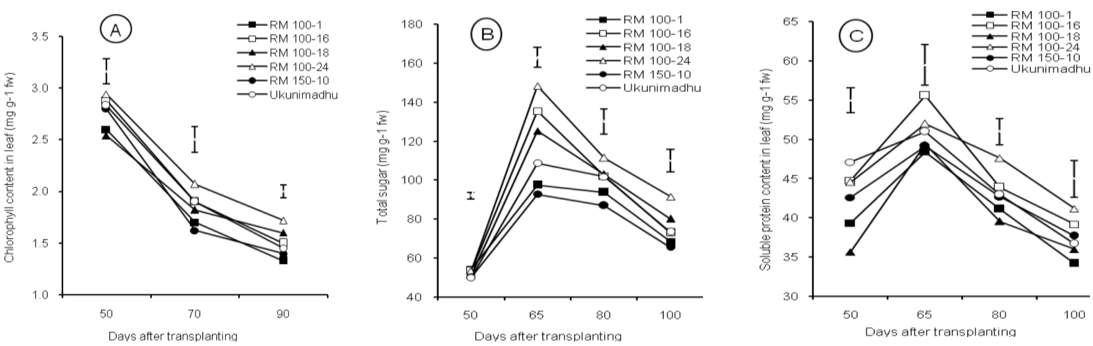

Fig. 2. Changes in (A) chlorophyll, (B) total sugar and (C) soluble proteincontent in leaf of five aromatic mutants along with mother at different growth stages. Vertical bars represent LSD$_{(0.05)}$

Grain yield and yield attributes:

Number of effective and non-effective tillers $hill^{-1}$, number of filled and unfilled grains $panicle^{-1}$ and 1000-grain weight showed significant differences amongst the mutants/variety (Table 4). The mutant RM 100-24 produced the highest number of effective tillers $hill^{-1}$ (10.7) and grains $panicle^{-1}$ (173.0) and also showed the highest grain yield (4.26 t ha^{-1}) whilst showing the lowest in RM 150-10 (3.62 t ha^{-1}) and RM 100-1 (3.64 t ha^{-1}) due to inferior performance in yield attributes. Elayaraja *et al.* (2005) reported that the genotypes, which produced higher number of effective tillers $hill^{-1}$ and higher number of grains $panicle^{-1}$ also showed higher grain yield. Similar results were also reported by Mondal *et al*. (2005) and Oladosu*et al.* (2014) in rice.

Table 4. Yield and yield attributes of five aromatic rice mutants along with mother

Mutants/variety	Effective tillers/hill (no.)	Non-effective tillers $hill^{-1}$ (no.)	Filled grains $panicle^{-1}$ (no.)	Unfilled grains/panicle (no.)	1000 grain wt. (g)	Grain wt./hill (g)	Grain yield (t ha^{-1})
RM 100-1	8.33 cd	1.40 b	118.3 d	21.33 ab	11.89 a	39.01 bc	3.64 c
RM 100-16	9.67 b	1.20 c	146.3 bc	14.00 c	11.24 b	42.14 ab	4.01 b
RM 100-18	9.60 b	1.60 a	137.0 c	24.67 b	11.50 ab	40.83 ab	3.84 bc
RM 100-24	10.7 a	0.80 d	173.0 a	19.67 ab	10.33 c	43.92 a	4.26 a
RM 150-10	7.80 d	1.50 a	149.7 bc	22.33 ab	10.19 c	37.98 c	3.62 c
Ukunmodhu (mother)	9.13 bc	1.40 b	160.0 ab	25.00 a	10.97 b	42.11 ab	4.00 b
F-test	**	**	**	*	*	*	**
CV (%)	6.43	6.80	6.04	12.65	3.36	5.42	2.05

In a column same figure (s) do not differ significantly at $P \leq 0.05$ as per DMRT;
* and ** indicate significant at 5% and 1% levels of probability, respectively.

From the study, it is evident that out of five mutants, RM 100-24 showed superiority in respect of growth, biochemical parameters and grain yield, and also seven days earlier matured compared to its mother, Ukunimadhu, which reflected that RM 100-24 may be selected effectively to be a physiological superior mutant. This mutant may be released as high yielding fine grain aromatic rice variety after several yield trails under farmers' field conditions at different agro-ecological zones of the country.

References

Ashrafuzzaman, M., M.R. Islam, M.R. Ismail, S.M. Shahidullah, and M.M. Hanafi, 2009. Evaluation of six aromatic rice varieties for yield and yield contributing characters. Int. J. Agric. Biol. 11:616–620.

BARC. 2005. Fertilizer Recommendation Guide. Bangladesh Agricultural Research Council (BARC), Farmgate, Dhaka-1215. p. 34.

BBS (Bangladesh Bureau of Statistics). 2015. Hand book of Agricultural Statistics, December, 2015. Ministry of Planning, Govt. People's Repub. Bangladesh. p. 24.

Dubois, M., Gilles, K.A., Hamilton, J.K., Robers, P. A. and Smith, F. 1956. Colorimetric method for determination of sugars and related substances. Anal. Chem. 28: 350-356.

Dutta, R. K. 2001. Assessment of the advanced mutant lines/varieties of BINA with emphasis on physiological criteria. Report on ARMP Project no. 112, BARC, Farmgate, Dhaka 1215. pp. 52-53.

Elayaraja, K., Prakash, M., Saravanan, K., Kumar, S.B. and Ganesan, J. 2005. Studies on variability, heritability and genetic advance for certain quantitative characters in mutant population of rice (*Oryza sativa* L.), Crop Res. Hisar1: 134–137.

Hunt, R. 1978. Plant growth analysis studies in biology. Edward Arnold Ltd. London. p. 67. J. Bio-Sci. 17: 77-82.

Lowry, O.H., Rosebrough, N.J., Farr, A.L. and Randall, R.J. 1951. Protein measurement with Folin phenol reagent. J. Biol. Chem. 193: 265-275.

Malek, M.A., Mondal, M.M.A., Ismail, M. R., Rafii, M.Y. and Berahim, Z. 2012. Physiology of yield in soybean: Growth and dry matter production. African J. Biotech. 11:7643-7649.

Mondal, M.M.A., Fakir, M.S.A., Islam, M.N. and Samad, M.A. 2011. Physiology of seed yield in mungbean: growth and dry matter production. Bangladesh J. Bot. 40: 133-138.

Mondal, M.M.A., Islam, A.F.M.S. and Siddiquee, M.S.K. 2005. Performance of modern transplant aman rice varieties under farmers' management conditions in the Rangpur-Dinajpur region of Bangladesh. Bangladesh J. Crop Sci. 16: 51-57.

Mondal, M.M.A., Puteh A.B., Kashem M.A., Haque, M.A. and Razzaque A.H.M. 2014b. Growth and dry matter partitioning in plant parts of lentil. Legume Res. 37 (4): 434-438.

Mondal, M.M.A., Puteh, A.B, Malek, M.A., Ismail, M.R., Rafii, M.Y. and Latif, M.A. 2012. Seed yield in relation to growth and developmental aspects of mungbean. The ScientificWorld J., Vol. 2012: doi:10.1100/2012/425168.

Mondal, M.M.A., Puteh, A.B., Ismail, M.R. ans Rafii, M.Y. 2013. Optimizing plant spacing for modern rice varieties. Int. J. Agric. Biol.15 (1): 175-178.

Mondal, M.M.A., Puteh, A.B., Kashem, M.A. and Hasan, M.M. 2014a. Effect of plant density on canopy structure and dry matter partitioning into plant parts of soybean. Life Sci.J. 11 (3): 67-74.

Oladosu, Y., Rafii, M.Y., Abdullah, N. Malek, M.A., Rahim, H.A., Hussin, G., Latif, M.A. and Kareem, I. 2014.Genetic variability and selection criteria in rice mutant lines as revealed by quantitative traits. The Scientific World J. Volume 2014, http://dx.doi.org/10.1155/ 2014/190531

Prasad, B, Patwary, A.K. and Biswas, P.S. 2001. Genetic variability and selection criteria in fine rice. Pak. J. biol. Sci. 4: 1188-1190.

Puteh , A.B. and Mondal, M.M.A. 2014. Growth and yield performance of rice as affected by nitrogen rate. Life Sci.J. 11 (8): 653-655.

Puteh A.B., Mondal, M.M.A., Ismail, M.R. and Latif, M.A. 2014. Grain sterility in relation to dry mass production and distribution of rice. Biomed Res. Int. dx.doi.org/10.1155/ 2014/ 302179

Rahman, M.A. Haque, M.E., Sikdar, B., Islam, M.A. and Matin M.N. 2013. Correlation analysis of flag leaf with yield in several rice cultivars. J. Life Earth Sci. 8: 49-54.

Russell, D. F. 1986. MSTAT-C Pakage Programme. Crop and Soil Science Department, Michigan University, USA.

Shahidullah, S.M., Hanafi, M.M., Ashrafuzzaman, M., Ismail, M.R., Salam, M.A. and Khair, A. 2010. Biomass accumulation and energy conversion efficiency in aromatic rice genotypes. Comptes Rendus Biol. 333: 61–67.

Sharma, S.K. and Haloi, B. 2001. Characterization of crop growth variable in some selected rice cultivars of Assam. Indian J. Plant Physiol. 6: 166-171.

Yoshida, S., Forno, D.A., Cock, J.A. and Gomes, K.A. 1976. Laboratory manual for physiological studies of rice. 3rd ed., IRRI, Los Banos, Philippines.

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PROFITABILITY ANALYSIS OF SUBMERGENCE TOLERANT RICE VARIETY BINADHAN-11

S. Islam, M. R. Haque, M. M. A. Sarker and R. Sultana

Abstract

The study was conducted in four major Binadhan-11 growing areas, namely Mymensingh, Sherpur, Jamalpur and Kurigram of Bangladesh. The average cost of production of Binadhan-11 is Tk. 44642.28 per hectare. The major share of total cost was human labour, power tiller and fertilizers. The cost of Binadhan-11 cultivation was found higher in Mymensingh (Tk. 47646.89 ha^{-1}) followed by Sherpur, Jamalpur and Kurigram were Tk. 45970.44, Tk. 42483.90 and Tk. 42467.88 ha^{-1}, respectively. The net returns of Binadhan-11 were Tk. 33873.64, Tk. 31082.65, Tk. 17566.42 and Tk. 21583.28 ha^{-1} followed by Mymensingh, Sherpur, Jamalpur and Kurigram, respectively. In the study area, the highest net return was found in Mymensingh district (Tk. 33873.64 ha^{-1}) and the lowest was in Jamalpur district (Tk. 17566.42 ha^{-1}). The average net return of Binadhan-11 was Tk. 26026.50 ha^{-1}. The average Benefit cost ratio was 1.58 indicates that cultivation of these variety is profitable to the farmer's level when all sorts of cost were taken into consideration. The highest BCR was found in Mymensingh district (1.71) which was followed by Sherpur (1.68), Kurigram (1.51) and Jamalpur (1.41) districts, respectively. However, the sample farmers were profitable to cultivate Binadhan-11 in the study area. The reasons that hamper the achievement of goals are defined as problems whereas suggestions are indications of some measures to overcome these problems.

Key words: Binadhan-11, Profitability, Cost, Return and Problem.

Introduction

Rice is an important submergence tolerant rice variety in Bangladesh due to its higher yield, nutritional value and versatile uses. Demand of rice in Bangladesh is augmenting day by day as Bangladesh is the 8th most populous country in the world with a total population of 155.8 million, population growth rate is 1.37% (BER, 2017) and its density of population is 1077 persons per Km^2 (BER, 2017). More than 70% of the country's population as well as 45.01% of its labour force directly and indirectly depend on agriculture and contribute 14.79% to the GDP (BBS, 2017). High production of rice depends on the expansion of HYV and saline tolerable variety of seeds, improved management and timely supplying of inputs. The rate of adoption of modern technology and sustainability of rice production depend largely on its economic profitability. The efficient use of resources is an important indicator of increased production in agriculture. Efficient utilization of present level of inputs is indispensable for higher productivity.

Agricultural Economics Division, Bangladesh Institute of nuclear Agriculture, Mymensingh-2202, Bangladesh

In Bangladesh, the problem of food deficit can best be met by increasing rice production. The desirable characteristics of rice hashigher yield than other cereals, well suitability to the rain fed condition and higher nutrition status. The people of Bangladesh can meet the calories requirements by increasing rice production.

In Bangladesh, coastal areas constitute about 2.5 million hectare which amounts to about 25 percent of total crop land of the country. Of this, nearly 0.84 million hectare is affected by varying intensities of salinity (Karim et al 1990). Salinity Intrusion in Interior Coast found that the increasing concentration of salinity will create more pressure to the farmer by reducing yield and threatening livelihood, income generation and food security (Lubna and Baten, 2012). According to Sikder (2012), Bangladesh is one of the worst affected countries that are facing the early impacts of climate change particularly in agricultural sector. Razzaque and Zaman (2007) carried out a study on comparative analysis of T. aman rice cultivation under different management practices in coastal area where demonstration plots showed higher benefit cost ratio than non-demonstration plot. Haque (2006) studied the salinity problems and crop production in coastal reason of Bangladesh which showed that about 53% of the coastal areas are affected by salinity. In addition, Singh (2003) showed that contract farming as a system affected growers positively or negatively depends on the context of the economy. Rahman and sattar (2013) conducted a study on IRRI supported submergence tolerant rice variety in Bangladesh and found it was profitable. However, studies regarding the profitability of rice in submergence areas of Bangladesh are very few, that is why, the present study had been taken for measuring profitability of rice production in submergence areas of Mymensingh, Sherpur, Jamalpur and Kurigram district for a successful rice revolution in Bangladesh and expected to provide valuable data and useful for formulating appropriate policy for widespread cultivation of rice insubmergence areas of Bangladesh. The objectives were i) to estimate the cost and return of the submergence tolerant rice variety binadhan-11; and ii) to identify the major problem faced by the Binadhan-11grower farmers.

Materials and Method

The study was conducted in four major Binadhan-11 growing areas of Bangladesh, namely Mymensingh, Sherpur, Jamalpur and Kurigram. A total of 120 farmers were randomly selected as sample size by using multi-stage sampling method in the study area, 30 from each district. Data were collected from Binadhan-11 growers through interview schedule. Some descriptive statistics were used for analyzing the data. In the study, costs and return analyses were done on full cost basis.

Profitability analysis of rice production has been determined on the basis of net return. To determine the net returns from rice production, gross costs (variable and fixed cost) were deducted from gross returns. For this purpose, the following equation was used (Dillon and Hardaker, 1993).

The equation has been applied for each of the selected farmers:

$$\pi = Y_m*P_m+Y_b*P_b - \Sigma (X_i* P_{xi})\text{-TFC}$$

Where,

π = Net return; Y_m= Total quantity of main product; P_m= Price of main product per units; Y_b= Quantity of by-product; P_b = Price of by-product per unit; X_i= Quantity of the i^{th} input used for rice production; P_{xi}= Price of i^{th} input per unit used for rice production; TFC = Total fixed cost i = 1, 2, 3...........................n (number of input)

The estimation of interest on operating capital (IOC) was as follows:

Interest on OC = AI × i × t

Where, AI = (Total investment)/2;

I = Rate of interest per annum (%); and T = Period of rice production (in month).

The benefit cost ratio (BCR) is a relative measure which is used to compare benefit per unit of cost. Benefit-cost ratio is the ratio of present net worth of benefit and present net worth of cost. It indicates that the benefit of per unit cost at present worth.

$$\text{Benefit – Cost Ratio (BCR)} = \frac{\text{Present net worth of benefits}}{\text{Present net worth of cost}}$$

Result and Discussion

The average production cost of Binadhan-11 was Tk. 44642.28 ha^{-1}. The major share of total cost was human labour, power tiller and fertilizers. The cost of Binadhan-11 cultivation was found higher in Mymensingh (Tk. 47646.89 ha^{-1}) followed by Sherpur (Tk. 45970.44), Jamalpur (Tk. 42483.90) and Kurigram (Tk. 42467.88 ha^{-1}).

From Table 2, it is showed that the average yield of Binadhan-11 was 4250.75 kg (4.3 t ha^{-1}) per hectare. The gross return of Biandhan-11cultivation was found higher in Mymensingh (Tk. 81520.53 ha^{-1}) followed by Sherpur, Jamalpur and Kurigram in Tk. 77053.09, Tk. 60050.18 and Tk. 64051.16 ha^{-1} among the study areas. The net returns were Tk. 33873.64, Tk. 31082.65, Tk. 17566.42 and Tk. 21583.28 per hectare followed by Mymensingh, Sherpur, Jamalpur and Kurigram, respectively. In the study area, the highest net return was found in Mymensingh district (Tk. 33873.64 ha^{-1}) and the lowest was in Jamalpur district (Tk. 17566.42 ha^{-1}). The average net return was Tk. 26026.50 ha^{-1}.

The average benefit cost ratio was 1.58 indicates that cultivation of the variety is profitable to the farmer’s level when all sorts of cost were taken into consideration. The highest BCR was found in Mymensingh district (1.71) which was followed by Sherpur (1.68), Kurigram (1.51) and Jamalpur (1.41) districts, respectively.

Table 1. Cost of submergence tolerant rice variety Binadhan-11

Cost component	Mymensingh	Sherpur	Jamalpur	Kurigram	Average
Human labour (man-days ha^{-1})	22525.21	21500.91	18800.78	19266.71	20523.40
Power tiller ($Tk.ha^{-1}$)	5350.00	5430.48	5000.13	4860.48	5160.27
Seed ($Tk.ha^{-1}$)	1350.34	1400.67	1250.08	1000.70	1250.45
Fertilizer ($Tk.ha^{-1}$)	**8940.42**	**8541.37**	**8132.07**	**8181.68**	**8448.89**
Urea ($Tk.ha^{-1}$)	3640.13	3580.81	3400.66	3600.25	3555.46
TSP ($Tk.ha^{-1}$)	3370.08	3170.42	3050.56	2980.78	3142.96
MP ($Tk.ha^{-1}$)	1930.21	1790.14	1680.85	1600.65	1750.46
Pesticides ($Tk.ha^{-1}$)	4100.26	3800.89	4200.12	4000.35	4025.41
Irrigation ($Tk.ha^{-1}$)	2680.08	2964.66	2470.43	2717.14	2708.08
Interest on operating capital ($Tk.ha^{-1}$)	1420.37	950.25	1580.08	1040.61	1247.83
Total variable cost ($Tk.ha^{-1}$)	**46366.68**	**44589.23**	**41433.69**	**41067.67**	**43364.32**
Total Fixed cost ($Tk.ha^{-1}$)	1280.21	1381.21	1050.21	1400.21	1277.96
Total Cost	**47646.89**	**45970.44**	**42483.90**	**42467.88**	**44642.28**

Table 2. Profitability of submergence tolerant rice variety Binadhan-11

Items	Mymensingh	Sherpur	Jamalpur	Kurigram	Average
Yield (kg ha^{-1})	4910.00	4728.00	3550.00	3815.00	4250.75
Yield (Tk. ha^{-1})	72160.41	69552.33	53250.14	57750.68	63178.39
By product (Tk. ha^{-1})	9360.12	7500.76	6800.18	6300.48	7490.39
Gross return ($Tk.ha^{-1}$)	**81520.53**	**77053.09**	**60050.32**	**64051.16**	**70668.78**
Total variable cost ($Tk.ha^{-1}$)	46366.68	44589.23	41433.69	41067.67	43364.32
Total cost ($Tk.ha^{-1}$)	47646.89	45970.44	42483.90	42467.88	44642.28
Gross margin ($Tk.ha^{-1}$)	35153.85	32463.86	18616.63	22983.49	27304.46
Net returns ($Tk.ha^{-1}$)	**33873.64**	**31082.65**	**17566.42**	**21583.28**	**26026.50**
Benefit cost ratio (Undiscounted)	**1.71**	**1.68**	**1.41**	**1.51**	**1.58**

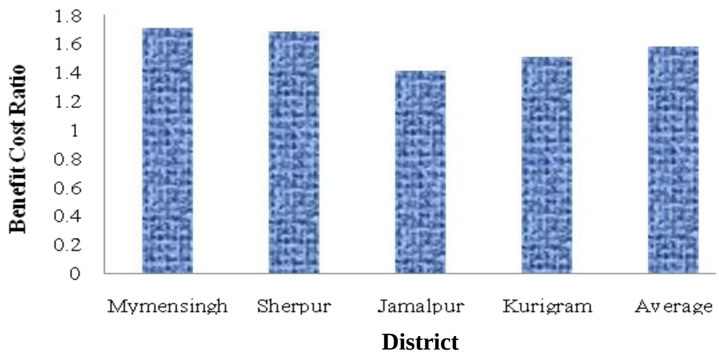

Fig. 1. Undiscounted Benefit Cost Ratio

Problems and Constraints of Farmers and Its Probable Solutions

The reasons that hamper the achievement of goals are defined as problems whereas suggestions are indications of some measures to overcome these problems. The farmers faced various problems which are discussed below:

Scarcity of farm labour and high wage rate

Though the labourers are available in Bangladesh but most of them are unskilled and in the peak period the required labour was not available in the study area. In the farms most of the labourers, were totally illiterate. They did not help in scientific way, which reduce wastage in the production process. About 72, 61, 65 and 80 percent farmers of Sherpur, Jamalpur, Kurigram and Mymensingh districts, respectively claimed this problem in the study area. All most 70 percent the farmers reported this problem on an average. To overcome this problem, the mechanization system should be developed.

Adulterated fertilizers and insecticides

The effectiveness of the used fertilizers and insecticides were very lower in quality reported by almost all the respondents in the following study. Sometimes the adulteration rate was very much higher in fertilizers and insecticides that the farmers had to face the loss the cultivation of Binadhan-11. About 75, 75, 80 and 65 percent farmers of Sherpur, Jamalpur, Kurigram and Mymensingh districts, respectively reported that the fertilizers were adulterated. To solve this problem, govt. should take to implement the law and order properly through the law enforcement agencies.

Table 3. Major problems faced by the farmers under different districts

Name of the problems	Districts				
	Sherpur (%)	Jamalpur (%)	Kurigram (%)	Mymensingh (%)	Average (%)
Scarcity of farm labour and high wage rate	72	61	65	80	69.50
Adulterated fertilizer and insecticide	75	75	80	65	73.75
Short supply and high price of fertilizers	85	80	90	95	87.50
Lack of credit facilities	80	70	75	80	76.25
Transportation problem	55	62	85	57	64.75
Lack of adequate market information	65	65	70	50	62.50

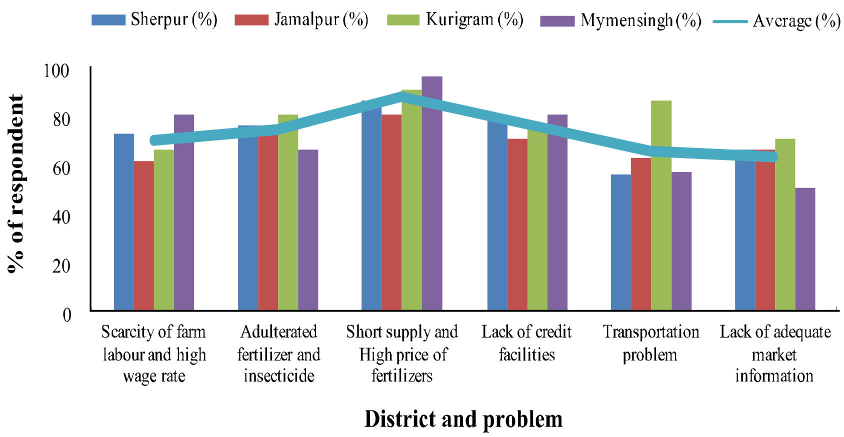

Fig. 2. Major problems faced by the farmers

Short supply and high price of fertilizers

Fertilizers were the important inputs in rice production. That's why the price hike in fertilizers was very much burning issue to be discussed by the farmers as they were interviewed. About 85, 80, 90 and 95 percent farmers of Sherpur, Jamalpur, Kurigram and Mymensingh districts, respectively reported this problem. On an average about 88 percent farmers reported this problem as one of the major problems. The government should take initiative to higher subsidy and proper maintenance of supply and market channel to solve this problem.

Lack of credit facilities

Working capital is an important factor for the farmers. Most of the farmers reported that they suffered from shortage of necessary capital during the operation of rice cultivation. Due to shortage of working capital the farmers could not purchase necessary inputs in a large volume to meet up their demand in lean period. In the study area, About 85, 70, 75 and 80 percent farmers of Sherpur, Jamalpur, Kurigram and Mymensingh districts, respectively reported this problem. The govt. and NGOs should take initiative to increase the credit facilities for the farmers.

Transportation problem

The transportation problems were different for different modes of transportation as well as for different market locations. Transportation problem becomes serious in the peak period of Aman and Boro seasons. The transportation cost is higher in those seasons compare to rest of the year. In the study area, on an average 65 percent farmers reported this problem. This problem can be solved by the ministry of LGRD and co-operatives to implement the proper steps.

Lack of adequate market information

Lack of adequate market information was a problem for the farmers. The farmers could not collect market information rapidly due to the shortage of support service from the government. About 65, 65, 70 and 50 percentage farmers of Sherpur, Jamalpur, Kurigram and Mymensingh districts, respectively reported about this problem and the average shows that 63 percent farmers of all farming systems reported this kind of problem. Adequate market information should be provided by the media and other informants.

Other Problems

Besides the problems, which are discussed above, the farmers have to face some risk and uncertainties, which sometimes causes severe losses. These risks may arise due to various internal and external activities such as inadequate irrigation facilities Lack of technical knowledge, Homestead and village erosion vulnerability.

Conclusions

It is evident from the above-mentioned discussion that the sample farmers were profitable to cultivate Binadhan-11 in the study area. But some problems and factors were influenced it's profit throughout the production process. If the farmers become more conscious and use modern implements in agricultural production activities, they will get maximum profit from the cultivation of Binadhan-11. Submergence tolerant rice variety, Binadhan-11 should be disseminated throughout the country where frequent or flash flood is a problem.

References

BBS. 2017. Statistical Yearbook of Bangladesh, Bangladesh Bureau of Statistics, Stat. Div., Min. of Planning, Govt. of the People's Republic of Bangladesh, Dhaka.p. 12.

BER. 2017. Bangladesh Economic Review. Economic Adviser's Wing, Planning Division, Min. of Finance, Govt. of the People's Republic of Bangladesh. p. 55.

Dillion, J.L. and Hardaker, J.B. 1993. Farm Management Research for Small Farmer Development, FAO Pub., Rome, Italy.

Haque, S.A. 2006. Salinity problems and crop production in coastal regions of Bangladesh. Pakistan J. Bot. 38: 1359-1365.

Karim, Z., Hussain, S.G. and Ahmed, M. 1990. Salinity problems and crop intensification in the coastal regions of Bangladesh, Bang. Agri. Res. Council (BARC), Dhaka. 13: 13-32.

Lubna, S. and Baten, M.A. 2012. Salinity intrusion in interior coast: A new challenge to agriculture in south central part of Bangladesh. Bangladesh J. Agric. Res. 38: 250-252.

Rahman, M.S. and Sattar, N. 2013. Adoption performance of IRRI supported submergence tolerant rice variety in Bangladesh. Bangladesh J. Polit. Econ. 5: 09-24.

Razzaque, M.A. and Rafiquzzaman, S. 2007. Comparative analysis of T. aman rice cultivation under different management practice in coastal area.J. Agri. and Rural Dev. 4: 64-69.

Sikder, T.M. 2012. The impacts of climate change on the coastal belt of Bangladesh: An investigation of risks & adaptations on agricultural sector. Proc. Int. Conf. Env. Asp. Bangladesh (ICEAB10), Japan.

Singh, S. 2003. Theory and practice of contract farming: A review. J. Social and Econ. Dev. 18: 228-246.

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CDR EVALUATION OF GC-5000 USING CERIC-CEROUS AND GAMMA CHROME DOSIMETERS

S. H. Bhuiya[1], M. M. H. Sohag[1], K. S. Arefin[1], N. Sultana[2]
Sham Hasan[3] and A. Bazlie Abdul Kadir[3]

Abstract

The reliability and accuracy of the dosimeter system play a vital role in the quality assurance of the gamma irradiator using in different fields, especially for the agricultural research. In order to estimate the Central Dose Rate (CDR) of ^{60}Co gamma irradiator (GC-5000) of Bangladesh Institute of Nuclear Agriculture (BINA), doses were evaluated using Ceric-Cerous and commercial Gamma Chrome dosimeters. The absorbed dose of Ceric-Cerous (~20kGy) dosimeters was measured using an electrochemical potentiometer cell in millivolts (mV) ranges while evaluation for absorbed dose of Gamma Chrome dosimeters (~3kGy) UV-VIS spectrometer of 304nm wavelength was used. The evaluated doses of Ceric-Cerous dosimeters are found to be 4.3±0.4, 12.5±0.7 and 20.3±0.4kGy corresponding to the delivered doses of 4.5, 13.0 and 20.7kGy, respectively while the absorbed dose of Gamma Chrome dosimeter to be found 2.3 ± 0.3kGy corresponding to the delivered dose of 2.5kGy. The results of this study establish both Ceric-Cerous and Gamma Chrome dosimeters are suitable for routine dosimetry on GC-5000 gamma irradiator.

Key words: CDR, Ceric-Cerous, Gamma Chrome, potentiometer, UV-VIS spectrometer.

Introduction

Gamma irradiator has been extensively used for seed irradiation, killing of fungus and micro organisms, sterilization of medical accessories and surgical equipments, high energy radiation chemistry, irradiation of foodstuffs and semiconductor irradiation (Clandson *et al*., 1972; Goresline, 1973; Snauert *et al*., 1973; Bhat *et al*., 1987; Meulenberg *et al.*, 1987; ISO/ASTM, 2002a, 2002). It needs careful characterization to determine the overall performance of the irradiator in delivering absorbed dose to a product prior to routine processing (Jerome Weiss, 1952). Since, Bangladesh Institute of Nuclear Agriculture (BINA) having the research mandate for peaceful use of nuclear technique in agricultural fields, an irradiation source of Gamma Chamber-5000 (GC-5000) for exposing experimental samples was commissioned by Board of Radiation and Isotope Technology (BRIT), Mumbai, India in 2013. The present source is still having higher dose rate. The equipment

[1]Bangladesh Institute of Nuclear Agriculture, BAU Campus, Mymensingh-2202, Bangladesh
[2]On Farm Research Division, Bangladesh Agricultural Research Institute, Mymensingh-2200, Bangladesh
[3]Malaysian Nuclear Agency, SSDL, Bangi, Malaysia

requires calibration from time to time for ensuring the delivery of required dose to experimental samples. The dose rate at the geometric center of the chamber i.e. the Central Dose Rate (CDR) of the equipment was 7.42 kGy/h during calibration at manufacturing site on September 21, 2012. On the day of work, the dose rates should be correctly ascertained from decay curve and absorbed dose calculated by applying relevant correction factors. Although, preliminary dosimetry was done by BRIT, Mumbai, it was felt necessary to do dose distribution studies inside the gamma chamber precisely. This becomes more relevant as this instrument is being used by various scientific working conditions like mutation breeding, sterile insect technique, biotechnological and plant pathological aspects.

The Ceric-Cerous sulfate chemical dosimeter has long been used for the measurement of large radiation doses (Hart *et al*., 1958; Harlan and Hart, 1959; Taimuty *et al*., 1959). The absorbed-dose range of interest is from ~0.5 to 100 kGy, giving it one of the widest ranges of any dosimeter. From the view point of this concept as well as for estimating the CDR of ^{60}Co gamma source (GC-5000) of BINA, Ceric-Cerous (~20kGy) dosimeters were prepared at the Secondary Standard Dosimetry Laboratory (SSDL), High dose dosimetry unit of Malaysian Nuclear Energy. It is well recognized that the commercial Gamma chrome dosimeters have also been widely using as routine dosimeter in the gamma radiation facilities. In order to cross check the evaluated dose for the experiments using Ceric-Cerous dosimeters, dose was also evaluated using gamma chrome (~ 3kGy range) dosimeters.

Materials and Methods

Ceric-Cerous sulfate chemical dosimeter

Ceric-Cerous dosimiters of ~20 kGy were prepared at the SSDL of high dose dosimetry unit in Malaysian Nuclear Energy using the standard method as. At first 25.2gm of $(NH_4)_4Ce(SO_4)_4.2H_2O$ were dissolved in 2 litres of 0.4M H_2SO_4. After that 0.75ml H_2O_2 was added to get 0.02 M Ce^{3+}. The prepared solution was kept 14 days in the dark and cool place for testing the stability. During this 14 days absorbance was tested every two days interval by adding H_2O_2 in order to get the absorbance within the range 0.7-0.75. The dosimeter solution was then filled into the 5ml ampoules and sealed by the heat of gas flame. The calibration of the Ceric-Cerous dosimeter was performed against reference Fricke dosimeter which was also prepared at the SSDL of high dose dosimetry unit in Malaysian Nuclear Energy.

The reference Fricke dosimeters were calibrated by the irradiation of reference ^{60}Co gamma source. In order to evaluate the dose rate of the reference gamma source, a secondary ionization chamber NE2581 was used. The irradiation arrangements both for ionization chamber and Fricke dosimeters are found to be in Fig. 1 and Fig. 2, respectively. The PTW-Unidows 10005 electrometer was used to get the charge in nC/min.

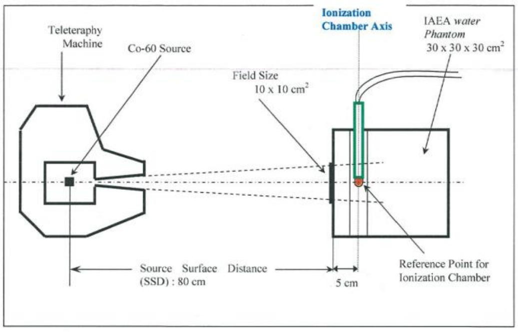

Fig. 1. Measurement of dose rate (standard) using secondary ionization chamber

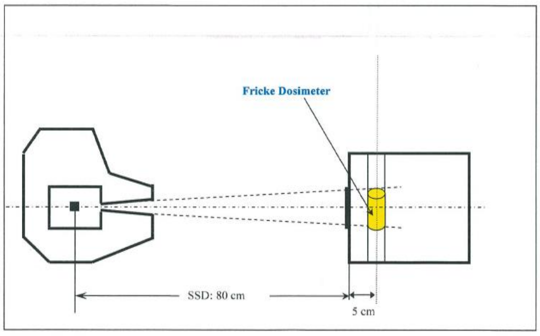

Fig. 2. Irradiation of Fricke Dosimeter

Gamma Irradiator GC-5000

The dosimetry measurements were carried out by the gamma irradiator of GC-5000 of Bangladesh Institute of Nuclear Agriculture (BINA). It is a compact, self-shielded type of ^{60}Co Gamma Irradiator. It has six main components: source, cylindrical source cage, lead flask as biological shield, central drawer with sample chamber, motorized mechanical drive system, Programable Logic Controller (PLC) based control system and external cabinet. The source cage is a shielded container having total 33 pencils of ^{60}Co radio-isotopes arranged symmetrically along its cylindrical periphery. The total activity of the gamma chamber was about 387.50TBq (10,473Ci) on September 13, 2012. The radiation source (^{60}Co) is a doubly encapsulated cylindrical pencil of 1.15 cm diameter and total length of 20.8 cm. The sample compartment with 5000cc. (approximately) of this irradiator is cylindrical in geometry of 17.2 cm diameter and 20.5 cm height. It is located in UK vertical shaft (drawer), which moves up and down with the help of a drive system, which enables exact positioning of the irradiator chamber in the center of the radiation field. The irradiator has a microprocessor based control system to operate the unit through the control panel which contains keypad and display for setting the irradiation parameters such as irradiation time, CDR, required dose, source ON/OFF etc. For this study, Ceric-Cerous routine dosimeters were placed at the center of the irradiation chamber vertically for evaluating the CDR (~20 kGy) of the irradiator. Similarly, routine dosimetry was performed at the same position and geometry of the irradiation chamber by using Gamma chrome dosimeters of Harwell, batch A, August, 2016 for evaluating the CDR (~3kGy) of the irradiator. In each case, the number of dosimeter was three for precise measurement.

Results and Discussions

Fricke and Cirec-Cerous dosimeters

As shown in Fig. 1, measurement of the standard dose rate (mGy/min.) of the reference gamma source using secondary ionization chamber was evaluated from the equation (1), where, R is the mean reading in nC/min. from Electrometer, K_{TP} is constant value evaluated from the room temperature and pressure and CF is the cofactor value of the ion chamber in mGy/nC. The standard dose (Gy) of the gamma irradiator was obtained using equation (1) by multiplying the total irradiation time. As shown in Fig. 2, the reference gamma source was also used to irradiate the Fricke dosimeters under identical conditions of Fig. 1 for the derivation of absorbed dose. The dose of Fricke was calculated using equation (2). The percentage of dose deviation found to be from equation (3). The dose deviation was obtained about -3% for Fricke. The routine dosimeters of Ceric-Cerous (~20kGy), those were prepared at the SSDL of Nuclear Malaysia have been used for the CDR evaluation of GC-5000 of BINA.

$$\text{Dose rate} = R \times (K_{TP}) \times (CF) \qquad (1)$$

$$\text{Dose (Fricke)} = \frac{275\,(A-A0)}{1+0.07\,(T-25)} \qquad (2)$$

$$\Delta\,(\text{delta}) = \frac{(\text{Standard dose} - \text{Dose Fricke})}{(\text{Standard dose})} \times 100\% \qquad (3)$$

Irradiation of Cirec-Cerous using GC-5000

In order to calibrate the gamma chamber of the GC-5000 Ceric-Cerous dosimetes were used. The process employed for the determination of absorbed dose is the reduction of ceric ions in a solution of ceric sulphate and cerous sulphate in 0.4M of sulfuric acid. The absorbed dose (Gy) of Ceric-Cerous dosimeters was obtained from the corresponding reading in milli volt (mV) of electrochemical potentiometer cell. As shown in Fig. 3, fitting the linear relation between the absorbed doses 4.3, 12.7 and 20.3Gy corresponding to the potentiometer readings of 5.2, 19.4 and 35.0mV equation (4) has been derived. The fitting shows an excellent correlation coefficient (R^2) of 0.996. It is assumed that Equ. (4) would be suitable for estimating the dose inside the irradiation chamber of GC-5000.

$$\text{Dose} = 1.859 \times (\text{reading in mV}) - 3.253 \qquad (4)$$

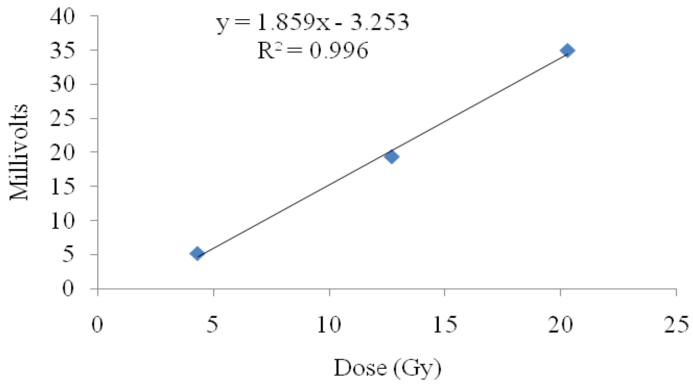

Fig. 3. Calibration curve for dose measurement using Ceric-Cerous dosimeters.

Irradiation of Ceric-Cerous and Gamma Chrome using GC-5000

Table 1 indicates the measured doses (kGy) absorbed by Ceric-Cerous and gamma chrome dosimeters corresponding to the delivered doses (kGy) from the central point of the irradiation chamber of GC-5000. It is mentioned that the delivered dose and irradiation time are automatically estimated by the programmable logic control unit integrated with the irradiator. The absorbed dose of Ceric-Cerous dosimeters was evaluated using an electrochemical potentiometer cell in millivolts (mV) ranges while evaluation for absorbed dose of gamma chrome dosimeters UV-VIS spectrometer of 304nm wavelength was used. Dose within the range 3~20Gy was measured by Ceric-Cerous dosimeters whereas dose ~3Gy was measured by gamma chrome dosimeters. In each case, the number of irradiation was three for precise measurement. It is found to be within the uncertainties measured doses are in line with delivered doses for both the dosimeters with in desired range.

Table 1. Evaluated dose corresponding to delivered dose for Ceric-Cerous and Gamma chrome

Irradiation No.	CDR of source (kGy/hr)	Dose delivered (kGy)	Irradiation Time (hr.)	Dose measured (kGy) Gamma chrome	Dose measured (kGy) Ceric-Cerous
1	4.47	2.54	0.57	2.40±0.30	-
2	4.47	4.48	1.01	-	4.30±0.40
3	4.45	13.00	2.92	-	12.70±0.60
4	4.45	20.70	4.66	-	20.30±0.40

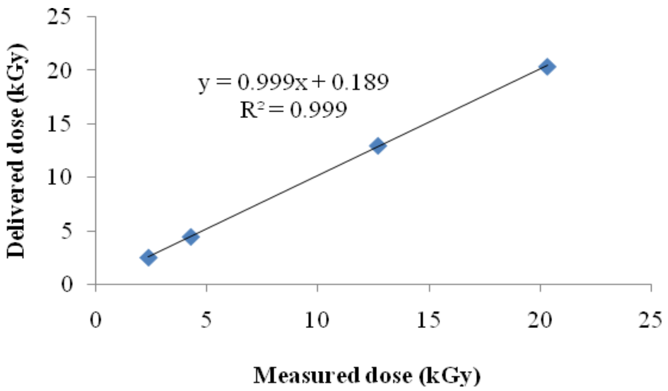

Fig. 4. Calibration curve for dose measurement with Ceric-Cerous and Gamma chrome dosimeters.

Absorbed dose = 0.999 × (Delivered dose) + 0.189 (5)

As shown the calibration curve in Fig. 4, fitting the linear relation between the absorbed doses i.e. measured doses corresponding to the delivered doses equation (5) has been derived. The fitting also shows an excellent correlation coefficient (R^2) of 0.999. It is assumed that Equ. (5) would also be suitable for reliable and precise dose mapping inside the irradiation chamber of GC-5000.

Conclusions

The Gamma Chamber-5000 of BINA can be used with routine dosimetry either by Ceric-Cerous (~20ky) or gamma chrome (~3Gy) in order to irradiate different experimental samples precisely, especially for plant mutation breeding and radiation processing technology of agricultural commodities. Further study could be carried out for dose mapping inside any point of the irradiation chamber.

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References

Bhat, M.A., Wajahat, H., Surinder, A. and Surinder, K. 1987. A study of medical adiation exposure of the radiation workers. Five year follow up. Bull. Radiation Protect. 10:149-152.

Clandson, T.T., Sinclair, E.E., Frost B.R.T., Bottax, A, Peareman, H., Spalaris, C.N. and Weir, J.R. 1972. Fundamental behavior of structural materials in fast reactor environments. Peaceful uses of Atomic Energy. 10:459-477.

Goresline, H.E. 1973. Status and prospects of food irradiation, Radiation preservation of food. Proceedings of a symposium, Bombay, Jointly organized by the IAEA and FAO. International Atomic Energy Agency, Vienna. pp. 32-36.

Harlan, J.T. and Hart, E.J. 1959. Ceric Dosimetry: Accurate Measurement at 104 Rads. Nucleonics 17:102-107.

Hart E.J., Koch H.W., Petree B., Schulman J.H., Taimuty S.I. and Wyckoff, H.O. 1958. Proceedings of the Second United Nations International Conference on the Peaceful Uses of Atomic Energy, Geneva. 21: 188-197.

ISO/ASTM, 2002. Standard Guide for Estimating Uncertainties in Dosimetry for Radiation Processing, ISO/ASTM Standard 51707-2002. American Society for Testing and Materials, Philadelphia, PA.

Jerome, W. 1952. Chemical Dosimetry Using Ferrous and Ceric Sulfates. Nucleonics. 10 and 28.

Meulenberg, A., Dozier, C.M., Anderson, W.T., Mittleman, S.D., Zugieh, M.H. and Caefer, C.E. 1987. Dosimetry of total dose radiation testing of Ga-As devices- IEEE Transactions on Nuclear Science 34 (6):1745-1750.

Snauert, F., Tobback, P.P., Verhces, J. and Maes, E. 1973. Radiation preservation of food. Influence of gamma rays on the chlorophyll content in peas. Proceedings of a symposium. Bombay. Jointly organized by IAEA and FAO. International Atomic Energy, Vienna. pp. 26-32

Taimuty S.I., Towle L.H. and Peterson D.L. 1959. Measuring Large Radiation Dose. Nucleonics Report. 17: 103-111.

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GENETIC VARIABILITY, CORRELATION, PATH ANALYSIS AND DIVERSITY STUDIES IN ADVANCED EARLY MATURING RICE GENOTYPES

H. M. Ershad[1], S. N. Begum[2], M. I. Khalil[3] and M. M. Islam[2]

Abstract

An experiment was carried out to evaluate the performances as well as to analyze correlation and path coefficient between yield and its components of three early maturing advanced rice lines (BINA E-1, BINA E-2, and BINA E-3) along with Binadhan-7. Significant variations were found among the genotypes for days to flowering, plant height, days to maturity, total tillers hill^{-1}, effective tillers hill^{-1}, filled grains panicle^{-1}, unfilled grains panicle^{-1}, 100-grain weight and grain yield. Days to flowering, days of maturity and 100-grain weight showed high heritability in broad sense. Path analysis revealed that effective tillers hill^{-1}, days to 50% flowering, filled grains panicle^{-1}, plant height and unfilled grains panicle^{-1} had positive direct effects on grain yield. Based on D^2-value, the genotypes were grouped into three clusters, Cluster I and III had one genotypes and Cluster II contained two genotypes. Genotypes belong to cluster I showed high number total tillers hill^{-1} and effective tillers hill^{-1}. The advanced line BINA E-3 was the earliest flowering as well as early maturing one and also produced the highest grain yield (5.35 t ha^{-1}). Among the lines the superior one may preferentially be used in future breeding program or eventually to be released as a variety for commercial cultivation.

Key words: Rice, genetic variability, heritability, correlation, path analysis.

Introduction

Rice (*Oryza sativa* L.) is the staple food for peoples of many countries. Bangladesh is the fourth largest producer and consumer of rice in the world with annual production about 34.7 million tons in the year 2015-16 (Anonymous, 2017). Rice alone contributes about 92% of the total food grain production annually in the country (Bhuiyan *et al.*, 2002). The global demand of rice will be 880 million ton in 2025 which is 70% more than that of present production (IRRI, 2010). But production is not increasing accordingly and agricultural lands are decreasing gradually due to urbanization and industrialization. Therefore, it is of prime importance to develop short duration and high yielding rice varieties for increasing the cropping intensity.

[1]Department of Biotechnology, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh
[2]Plant Breeding Division, Bangladesh Institute of Nuclear Agriculture, BAU Campus, Mymensingh-2202, Bangladesh
[3]Plant Pathology Division, Bangladesh Institute of Nuclear Agriculture, BAU Campus, Mymensingh-2202, Bangladesh

The knowledge of genetic variability present in a given crop species for characters under improvement is important for the success of any plant breeding programme (Bisne *et al.*, 2009). Heritability with genetic advance is more important selection parameter in case of crop improvement. Correlation studies would provide reliable information in nature, extent and the direction of the selection, especially when the breeder needs to combine high yield potentials with desirable agronomic traits and grain quality. A positive value of correlation shows that the changes of two variables are in the same direction, but when correlation is negative the movements are in opposite directions. The breeder is always concerned for the selection of superior genotypes on the basis of phenotypic expression. However for the quantitative characters, genotypes are influenced by environment, thereby affecting the phenotypic expression. The better way of exploiting genetic correlation and path coefficient with several traits having high heritability is to construct a selection index that combines information on all the characters associated with the dependent variable. The present investigation was therefore conducted to study the performance of yield and yield contributing characters in early maturing rice genotypes and to determine the variation and relationship among the individuals.

Materials and Methods

The experiment was carried out in the research field Bangladesh Institute of Nuclear Agriculture, Mymensingh during July 2012 to November 2012 using three advanced early maturing rice lines (BINA E-1, BINA E-2 and BINA E-3) along with the popular rice variety, Binadhan-7. The experiment was conducted following a randomized complete block design (RCBD) design with three replications. The plot size was 4.0 m x 2.5 m. Twenty six day old seedlings were transplanted in the plots maintaining row to row and plant to plant distances 20cm and 15cm, respectively. Fertilizers were applied at the recommended doses (Anonymous 2008). Intercultural operations and irrigation were done as and when necessary to raise good crop. Data were recorded on ten randomly selected plants from each replication for plant height, days to flowering, days to maturity, total tillers hill^{-1}, effective tillers hill^{-1}, filled grains panicle^{-1}, unfilled grains panicle^{-1}, 100-grain weight and grain yield.

Data were analyzed statistically for various characters by F-test and mean values were separated by LSD using computer based programme MSTATC. Heritability in broad sense (h^2_b) was estimated according to the formula used by Johanson *et al.* (1955). The genotypic and phenotypic correlation coefficients were estimated by the formulae suggested by Miller *et al.* (1958). Direct and indirect path coefficients were calculated as described by Lynch and Walsh (1998). Genetic diversity was calculated following Mahalanobis (1936).

Results and Discussions

The analysis of variance pertaining to different genotypes of nine important quantitative characters is shown in Table 1. Analysis of variance for the characters showed that there were significant variations among the genotypes for plant height, days to flowering, days to maturity, total tillers hill^{-1}, effective tillers hill^{-1}, filled grains panicle^{-1},

Table 1. Analysis of variance for different plant characters among four rice genotypes

Characters	d. f.	Days to 50% flowering	Days to maturity	Plant height (cm)	Total tillers hill^{-1} (No.)	Effective tillers hill^{-1} (No.)	Filled grains panicle^{-1} (No.)	Unfiled grains panicle^{-1} (No.)	100-grain weight (g)	Grain yield (t ha^{-1})
Replication	2	4.08	0.998	20.70	0.14	0.291	149.49	20.30	0.002	0.683
Genotypes	3	242.44**	5.188**	476.86**	20.07**	12.359**	13059.97**	3621.71*	0.018**	2.475**
Error	6	3.86	0.811	9.83	1.76	0.280	263.82	85.31	0.003	0.258

* and ** indicates significant at 0.05 and 0.01 probability, respectively

Table 2. Mean performance of different morphological characters of four rice genotypes

Genotypes	Days to 50% flowering	Days to maturity	Plant height (cm)	Total tillers hill^{-1} (no.)	Effective tillers hill^{-1} (no.)	Filled grains panicle^{-1} (no.)	Unfiled grains panicle^{-1} (no.)	100-grain weight (g)	Grain yield (t ha^{-1})
BINA E-1	54.33	120.00	104.33	9.87	8.67	439.3	62.30	2.49	4.95
BINA E-2	52.00	114.50	106.50	9.49	8.27	426.9	64.70	2.39	4.80
BINA E-3	44.33	105.00	97.15	10.75	9.73	472.4	57.80	2.55	5.35
Binadhan-7	45.00	112.00	98.60	10.10	9.22	467.9	59.30	2.52	5.15
$LSD_{0.05}$	5.11	2.34	8.15	3.45	1.37	42.21	24.00	0.142	1.23

unfilled grains panicle^{-1}, 100-grain weight and grain yield. This indicated that there was wide genotypic variation among the advanced lines for those characters. Significant genetic variations among the genotypes for different characters were also observed by Ratna *et al.* (2015) and Seyoum *et al.* (2012). Plant height differed significantly among the different genotypes (Table 2). BINA E-2 had shown the highest and BINA E-3 shown the shortest plant height. Plant height differed among the studied rice genotypes also reported by Hasan *et al.* (2011).

Among the rice genotypes, early 50% flowering was observed in BINA E-3 which took 44 days. In contrast, the maximum days required to 50% flowering for the genotype BINA E-1 as 54 days. Data indicated that days required to maturity also varied significantly among the genotypes. The genotypes BINA E-3 took the lowest days to mature (105 days) while BINA E-1 took the highest (120). These variations may be due to their different genetic makeup and climatic factors in the studied area.

The highest number of tillers and effective tillers hill^{-1} was found in BINA E-3 which produced 10.75 tillers hill^{-1} and 9.73 effective tillers hill^{-1}. The lowest number of total tillers hill^{-1} was found in BINA E-2 (9.49) and effective tillers hill^{-1} (8.27). The highest number of filled grains panicle^{-1} was found in BINA E-3 (472.4) followed by Binadhan-7 (467.9). Whereas, the lowest filled grains panicle^{-1} was found in BINA E-2 (426.2). Also the highest number of unfilled grains panicle^{-1} was found in BINA E-2 (64.2) and the lowest number of unfilled grains panicle^{-1} was BINA E-3 (57.8). Results showed that there was significant difference of 100-grain weight among the studied genotypes. The highest 100-grain weight (2.55 g) was recorded in BINA-E-3, in contrast, the lowest 100-grain weight was found in BINA E-2 (2.39 g). There was non-significant difference of grain yield among the studied genotypes observed. The highest yield (5.35 t ha^{-1}) was recorded in the genotype BINA E-3. In contrast, the lowest yield was found in BINA E-2 (4.80 t ha^{-1}).

Correlation coefficients:

Relationship between yield and yield contributing characters was studied through analysis of correlation between them. Result of correlation co-efficient at genotypic and phenotypic levels indicated that grain yield showed non-significant positive correlation with days to 50% flowering, days to maturity, total tillers hill^{-1}, effective tillers hill^{-1}, filled grains panicle^{-1}, unfilled grains panicle^{-1} and 100 grain weight (Table 3). A non-significant positive correlation of grains yield with 1st flowering, 50% flowering and weight of 100 grains were also observed by Das *et al.* (1992). Days to 50% flowering showed non-significant positive correlation with days to maturity, plant height, total tillers hill^{-1}, effective tillers hill^{-1}, filled grains panicle^{-1}, unfilled grains panicle^{-1} and yield. On the other hand, days to 50% flowering showed non-significant negative correlation with weight of 100 grains. Rao and Shrivastava (1999) reported significant positive correlation between days to 50% flowering with grain weight. But the result of correlation between days to 50%

flowering and weight of 100 grains were contradictory to the findings of Dhanraj *et al.* (1986) where two characters were negatively correlated. Days to maturity showed positive correlation with plant height, unfilled grains panicle^{-1}, weight of 100 grains and grain yield but negative correlation with total and effective tillers hill^{-1}, filled grains panicle^{-1} at the both genotypic and phenotypic level.

Table 3. Coefficients of genotypic (rg) and phenotypic (rp) correlation among different yield components in four rice genotypes

Characters		D50F	DM	PH	TTH	ETH	FGP	UGP	HGW	GY
D50F	rg		0.557	0.178	0.435	0.595	0.760	0.890	-0.505	0.935
	rp		0.512	0.171	0.433	0.591	0.755	0.878	-0.498	0.901
DM	rg			0.806	-0.602	-0.390	-0.194	0.169	0.433	0.791
	rp			0.814	-0.550	-0.367	-0.159	0.207	0.472	0.831
PH	rg				-0.728	-0.661	-0.509	0.091	0.603	0.568
	rp				-0.717	-0.662	-0.491	0.106	0.579	0.549
TTH	rg					0.946	0.908	0.595	-0.999**	0.004
	rp					0.970**	0.908	0.611	-0.970**	0.001
ETH	rg						0.978**	0.656	0.983**	0.180
	rp						0.975**	0.661	-0.934	0.184
FGP	rg							0.767	-0.950*	0.400
	rp							0.779	-0.896	0.396
UGP	rg								-0.750	0.709
	rp								-0.716	0.693
HGW	rg									0.183
	rp									0.090

D50F = Days to 50% flowering, DM = Days to maturity, PH = Plant height (cm), UGP= unfilled grains panicle^{-1},
TTH = total tillers hill^{-1}, ETH = effective tillers hill^{-1}, FGP = filled grains panicle^{-1}, HSW = 100 grain weight (g), GY = Grain yield (t ha^{-1}). * and ** indicates significant at 5% and 1% level of probability, respectively.

Plant height showed positive correlation with unfilled grains panicle^{-1}, weight of 100 grains, grain yield and negative correlation with total tillers hill^{-1}, effective tillers hill^{-1} and filled grains panicle^{-1}. Effective tillers hill^{-1} had significant positive association with number of unfilled grains and weight of 100 grains and positive correlation with grain yield. Effective tillers hill^{-1} showed positive significant association with filled grains panicle^{-1} in both genotypic and phenotypic level. On the other hand total tillers hill^{-1} also showed positive significant association with effective tillers hill^{-1} and positive effect on yield. Filled grains panicle^{-1} showed negative and non-significant association with 100 grain weight. This finding was partially in agreement with the results of Chaudhury and Das (1998). The results of the present study suggested that days to 50% flowering, plant height, effective tillers hill^{-1}, total tillers hill^{-1}, filled grains panicle^{-1} and yield were most important characters. Therefore, selection based on these characters may bring out desired improvement towards enhancing the grain yield in rice.

Estimates of heritability:

Estimates of heritability in broad sense indicated that 50% flowering, plant height, effective tillers hill^{-1} and filled grains panicle^{-1} were high heritable and it was 97.23, 95.37, 92.50, 94.06 93.50 and 94.18%, respectively (Table 4). High heritability for plant height and grain yield also reported by Akter *et al.* (2010). On the other hand, days to maturity, total tillers hill^{-1}, 100 grain weight (g) and yield (t ha^{-1}) were medium heritable and it was 64.27, 77.56, 62.50 and 74.12%, respectively.

Table 4. Heritability ($h^2{}_b$) of different traits of 4 rice genotypes

Traits	h^2b (%)
Days to 50% flowering	95.37
Days to maturity	64.27
Plant height (cm)	94.06
Total tillers hill^{-1}	77.56
Effective tillers hill^{-1}	93.50
Filled grains panicle^{-1}	94.18
100 grain weight (g)	62.50
Grain yield (t ha^{-1})	74.12

Path co-efficient analysis:

The maximum direct effects were contributed by effective tillers hill^{-1} (1.23) followed by days to 50% flowering (0.932), filled grains panicle^{-1} (0.752), plant height (0.432) and also unfilled grains panicle^{-1} (0.363) (Table 5). These five characters contributed maximum for yield. The direct effects of days to 50% flowering, effective tillers hill^{-1}, filled grains panicle^{-1} were higher than their respective correlation co-efficient but lower for plant height and unfilled grains panicle^{-1}. Chaudhury and Das (1998) observed high positive direct effect for days to maturity towards grains yield. Liu *et al.* (2001) reported the highest positive direct effect of filled grains panicle^{-1} on yield followed by 1000-grain weight and total tillers hill^{-1}. Chaubey and Singh (1994) observed the maximum positive direct effect of effective tillers hill^{-1} followed by plant height and 100 grain weight. Although days to 50% flowering was positively correlated with yield but its direct effect on grain yield was negative. It indicated that this character influenced grain yield by its indirect positive effects through days to maturity, plant height, unfilled grains panicle^{-1} and weight of 100 grains. Plant height showed a less positive direct effect on grain yield but the correlation co-efficient was significantly positive.

Table 5. Partitioning of phenotypic correlations into direct and indirect effects of ten important characters of four rice genotypes by path analysis (Bold figures indicate the direct effect)

Characters	DFF	D50F	DM	PH	TTH	ETH	FGP	UGP	HGW	GY
DFF	**0.932**	-0.515	-0.053	0.0783	-0.751	0.707	0.556	0.311	-0.0006	0.911
D50F	0.931	**-0.517**	-0.051	0.074	-0.799	0.729	0.567	0.319	-0.0007	0.901
DM	0.502	-0.264	**0.099**	0.352	1.010	-0.453	-0.119	0.075	0.0006	0.831
PH	0.168	-0.088	-0.081	**0.432**	1.320	-0.817	-0.369	0.038	-0.0008	0.549
TTH	0.379	-0.223	0.055	-0.310	**-1.850**	1.200	0.683	0.222	-0.0013	0.001
ETH	0.534	-0.305	0.036	-0.286	-1.790	**1.230**	0.733	0.240	-0.0013	0.184
FGP	0.689	-0.389	1.580	-0.212	-1.680	1.200	**0.752**	0.283	-0.0012	0.396
UGP	0.797	-0.453	-0.021	0.045	-1.130	0.815	0.585	**0.363**	-0.0010	0.693
HGW	-0.435	0.257	-0.047	0.250	1.790	-1.150	-0.674	-0.260	**0.0014**	0.090

Residual effect = 0.00204

DFF = Days to first flowering, D50F = Days to 50% flowering, DM = Days to maturity, PH = Plant height (cm), UGP=Unfilled grains panicle^{-1}, TTH = Total tillers hill^{-1}, ETH = Effective tillers hill^{-1}, FGP = Filled grains panicle^{-1}, HSW = Hundred grain weight (g), GY = Grain yield (t ha^{-1}).

Nature and magnitude of genetic diversity:

Using Euclidean distance following Ward's method, the genotypes were grouped into distinct clusters. Based on D^2-value, the genotypes were grouped into three clusters *viz.* I, II and III (Table 6). Cluster I and III had same number of genotypes. Cluster II contained only two genotypes. Thus, hybridization among genotypes drawn from these widely divergent clusters with high yield potential would likely to produce heterotic combinations and wide variability in segregating generations.

Table 6. Clustering pattern of four rice genotypes based on Mahalanobis' D^2-values and the number present in each respective cluster

Cluster number	Number of genotypes	Percent	Name of genotypes
I	1	25.00	BINA E-1
II	2	50.00	BINA E-2 and BINA E-3
III	1	25.00	Binadhan-7

Characterization of individual clusters:

Genotypes belong to cluster I showed high number total tillers hill^{-1} and effective tillers hill^{-1} than the rest of the clusters (Table 7). The maximum days to maturity, 50% flowering, filled grains panicle^{-1} , unfilled grains panicle^{-1} and grain yield were found in cluster III than other clusters and the minimum days to maturity was found in cluster I. Genotypes belong to cluster II showed taller plant (cm) and higher 100 grain weight (g).

Table 7. Cluster mean for yield and yield related characters in four rice genotypes

Characters	I	II	III
Days to 50% flowering	47.33 (I)	45.67 (L)	64.00 (H)
Days to maturity	87.00 (L)	89.25 (I)	90.00 (H)
Plant height (cm)	76.33 (L)	97.03 (H)	94.33 (I)
Total tillers hill^{-1}	13.87 (H)	8.80 (L)	12.40 (I)
Effective tillers hill^{-1}	11.67 (H)	8.20 (L)	11.60 (I)
Filled grains panicle^{-1}	536.27 (I)	441.16 (L)	567.93 (H)
Unfilled grains panicle^{-1}	116.33 (I)	67.80 (L)	152.33 (H)
100 grain weight (g)	2.39 (L)	2.54 (H)	2.43 (I)
Grain yield (t ha^{-1})	4.43 (L)	5.09 (I)	6.53 (H)

H= High value, I= Intermediate value, L= Low value

Conclusion:

Significant variations were found among the genotypes for all the characters studied. Days to flowering, days of maturity and 100-grain weight showed high heritability in broad sense. Path analysis revealed that five characters had positive direct effects on grain yield. Based on D^2-value, the genotypes were grouped into three clusters. The advanced line BINA E-3 was the earliest flowering as well as early maturing one and also produced the highest grain yield. Among the lines the superior one (BINA E-3) may be used in future breeding program or can be released as a variety for commercial cultivation.

References

Akter, T., Ivy, N.A., Rasul, G. and Mian, M.A.K. 2010. Variability and character association of reproductive traits in exotic rice germplasm. Bangladesh J. Plant Breed. Genet. 23: 39-43.

Anonymous. 2008. BINA Udvabito Unnata Krishi Projukti (in Bengali). Bangladesh Institute of Nuclear Agriculture (BINA). Mymensingh. Bangladesh. pp. 14-17.

Anonymous. 2017. Year Book of Agricultural Statistics 2016. Bangladesh Bureau of Statistics, Ministry of Planning, Government of the People’s Republic of Bangladesh. p. 49.

Bhuiyan, N.I., Paul, D.N.R. and Jabbar, M.A. 2002. Feeding the extra millions by 2025: Challenges for rice research and extension in Bangladesh. A key note paper presented at National workshop on rice research and extension, 29 December 2001 to 1 January 2002, Bangladesh Rice Research Institute, Gazipur. p. 9.

Binse, R., Sarawgi, A.K. and Verulkar, S.B. 2009. Study of heritability, genetic advance and variability for yield contributing characters in rice. Bangladesh J. Agril. Res. 34: 175-179.

Chaubey, P.K. and Singh, R.P. 1994. Genetic variability, correlation and path analysis of yield components of rice. Madras Agril. J. 81: 464-470.

Chaudhury, P.K.D. and Das, P.K. 1998 Genetic variability, correlation and path co-efficient analysis in deep water rice. Annals Agril. Res. 19: 120-124.

Das, R.K., Islam, M.A., Howlader, M., Ebrahim, S.M., Ahmad, H.V. and Miah, N.M. 1992. Variability and genetic association in upland rice (*Oryza sativa* L.). Bangladesh J. Plant Breed. Genet. 5: 51-56.

Dhanraj, A., Jagadish, C.A. and Vijay, B.U. 1986. Studies on character association in the F_2 generation of ten selected crosses in rice. J. Res. APAU. 15: 64-65.

Hasan, M.J., Kulsum, U., Rahman, M.H., Ali, M.H. and Julfiquar, W. 2011. Genetic variability of some cytoplasmic male sterile lines (CMS) of rice (*Oryza sativa* L.) genotypes. Bangladesh J. Agril. Res. 36: 263-270.

IRRI (International Rice Research Institute). 2010. Annual Report for 2009. International Rice Research Institute, Los Banos, Laguna, Philippines. pp.179-181.

Johnson, H.W., Robinson, H.F. and Comstock, R.E. 1955. Estimation of genetic and environmental variability in Soybean. Agron. J. 47: 314-318.

Liu, W., Shi, Y.L., Liu, W. and Shi, Y.L. 2001. Preliminary report on heterosis of japonica hybrid rice in Ningxia. Crop Ins. of Ningxia Aca. Agril. Forest Sci. Yongning 750105, Ningxia, China.

Lynch, M. and Walsh, B. 1998. Genetics and analysis of quantitative traits. Mol. Biol. Evol. 27: 526-530.

Miller, P.A., Williams, J.C., Robinson, H.F. and Comstock, R.E. 1958. Estimates of genetic and environmental variance and covariance and their implication in selection. Agron. J. 50: 126-131.

Rao, C.R. and Shrivastava, A.S.R. 1999. Genetic divergence among some brown plant hopper resistant rice varieties. Indian J. Genet. Plant Breed. 42: 179-185.

Ratna, M., Begum, S., Husna, A., Dey, S.R. and Hossain, M.S. 2015. Correlation and path coefficients analyses in basmati rice. Bangladesh J. Agril. Res. 40(1): 153-161.

Seyoum, M., S. Alamerew and Bantte, K. 2012. Genetic Variability, Heritability, Correlation Coefficient and Path Analysis for Yield and Yield Related Traits in Upland Rice (*Oryza sativa* L.). J. Plant Sci. **7**(1): 13-22.

Mahalanobis, P.C., 1936. On the generalized distance in statistics. Proc. National Inst. Sci. India, 2: 45-55

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EFFECT OF DIFFERENT FUNGICIDES IN CONTROLLING FOOT AND ROOT ROT OF LENTIL CAUSED BY *SCLEROTIUM ROLFSII*

A. Rokib[1], M.A. Kashem[2], M. J. Uddin[1] and M. S. Monjil[1]

Abstract

An experiment was conducted to determine the effect of different fungicides in controlling foot and root rot of lentil caused by *Sclerotium rolfsii* at Bangladesh Institute of Nuclear Agriculture, Mymensingh under inoculated pot soil condition. A root rot susceptible variety Binamasur-3 was used as a test crop. Six chemical fungicides, *viz.* Provax-200 (Carboxin+Thiram) @ 0.2%, Bavistin DF (Carbendazim) @ 0.1%, Dithane M-45 (Mancozeb) @ 0.4%, Secure (Mancozeb+Fenamidon) @ 0.2%, Antracol 70WP (Propineb) @ 0.3% and Deconil (Chlothalonil) @ 0.2% were used for seed treatment. The highest germination (100%) of lentil was found by treating seeds with Antracol followed by Secure (93.33%). The highest reduction of seedling mortality was noticed by treating seeds with Deconil (63.97%) followed by Secure (52.14%) over non treated control. The highest plant stand (74.91%) at harvest was found in the pots where the seeds were treated with Deconil followed by Secure (66.67%). The highest number of pods/plant (58.67) and highest number of healthy pods/plant (45.33) were found when the seeds were treated with Bavistin DF. The lowest number of infected pods/plant (4.33) and the highest hundred seed weight (3.67g) was noticed when seeds were treated with Deconil. In all cases, fungicides performed superiorly over control treatment.

Key words: Foot and root rot, *Sclerotium rolfsii*, Fungicides, Lentil.

Introduction

Lentil (*Lens culinaris* Medikus) is a short-statured, annual, self-pollinated, high value crop species. It is a leading pulse in many developing countries including Bangladesh. It can play an important role in fighting hunger and malnutrition, and in improving agricultural sustainability. FAO (2016) reported that global lentil production in 2014 was 4.83 million metric tons (MMT), the top producers being Canada (1.54 MMT), India (1.06 MMT), Australia (0.46 MMT), Turkey (0.44 MMT) and the United States of America (0.24 MMT). In Bangladesh, lentil is cultivated in an area of about 97400 ha with total production of about 1.57 lac ton (2% of global share) having an average yield of 1.26 tonha^{-1} (BBS, 2016), whereas average yield of the leading countries was around 1.5 ton ha^{-1} (FAO, 2016).

[1]Department of Plant Pathology, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh
[2]Plant Pathology Division, Bangladesh Institute of Nuclear Agricultural, BAU Campus Mymensingh-2202, Bangladesh

The low productivity of lentil in Bangladesh is attributed to many constraints. Among these, biotic factors particularly diseases play a major role. A number of soil borne as well as seed borne fungi are responsible for disease development which attack plants during seedling to maturity stages and are more destructive at seedling stage (Hoque*et et al*., 2014). Among the soil born fungi, *Sclerotium rolfsii* causing foot and root rot is an important pathogen. *S. rolfsii* is a polyphagous soil borne pathogen having a wide host range of more than 500 plant species in 100 families including crucifers, grasses and legumes that primarily attacks host stems including roots, fruits, petioles and leaves under favourable conditions (Punja, 2005).

Lentil is badly affected worldwide by foot and root rot disease as well as seedling blight (Bakr, 1993, Kaiser, 1992). Foot and root rot (*Fusariumoxysporum, F.solani and Sclerotium rolfsii*) is considered as the important and destructive disease of pulse in Bangladesh and also in almost all legume growing countries of the world (Fakir, 1983; Ahmed, 1985). In severe case, foot and root rot may cause yield loss up to 60-70% under favourable conditions (Tewari and Mukhopadhyay, 2003). It causes complete loss in grain yield if the disease occurs in the vegetative and reproductive stages of the crop (Navas *et al.,* 2000).

Seed treatment is an effective tool which is used to prevent germination failure and seedling infection as well as to destroy external and internal seed-borne pathogens and to develop a protective zone around the seed in the soil which protects the germinating seed and seedling from the attack of certain soil-borne pathogens (DeVay, 2001). Therefore, fungicidal seed treatments may be an important tool in reducing the incidence of foot and root rot disease of lentil caused by *S. rolfsii.*

Still, there is no effective control measure for the diseases. A few effective fungicides are available in the market. Few investigations have so far been conducted in the discipline of controlling foot and root rot of lentil by fungicides in Bangladesh (Hoque*et et al.* 2014). Considering the above fact, the present study was planned to evaluate the effectiveness of some fungicides available in the market against foot and root rot of lentil caused by *S. rolfsii*.

Materials and Methods

A pot experiment was conducted in the experimental site of Plant Pathology Division, Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh from August 2016 to March 2017. A root rot susceptible variety Binamasur-3 was used as a test crop. Ten seeds were sown in a pot (10L) inoculated with *Sclerotium rolfsii* (3 days before seed sowing). Disease development was observed regularly and recorded up to 30 days to determine the effect of pathogens on seedling mortality. The causal agent of seedling mortality was confirmed after re-isolation of the pathogen from infected roots. After confirmation, the experiment was set in completely randomized design having three replications each. Six chemical fungicides, viz. Provax-200 (Carboxin + Thiram) @ 0.2%, Bavistin DF (Carbendazim) @ 0.1%, Dithane M-45 (Mancozeb) @ 0.4%, Secure (Mancozeb + Fenamidon) @ 0.2%, Antracol 70WP (Propineb) @ 0.3% and Deconil (Chlothalonil) @ 0.2% were for seed treatment. One control treatment (soil inoculated with pathogens) was included for comparison.

A total of 75g mass culture (grown in sterilized chickpea) of *Sclerotium rolfsii* were inoculated in pot soil containing 4 kg soil per pot (dripped with 40% formalin solution @ 200 ml/cft soil) to every replication except control pots 48h before sowing seeds. Seeds were treated with the fungicides with their respective concentrations. Fifteen seeds were sown in each pot on 10th November 2016. Data were recorded on seed germination, seedling mortality, plant stand, shoot length/plant, root length, fresh weight of biomass, number of branches plant^{-1}, number of podsplant^{-1}, number of healthy podsplant^{-1}, number of infected podsplant^{-1} and 100 seed weight. The incidence of seedling mortality of lentil was calculated by the following formula:

$$\text{Incidence of seedling mortality (\%)} = \frac{\text{Number of dead plants}}{\text{Total number of plants germinated}} \times 100$$

The collected data were analyzed statistically following the analysis of variance (ANOVA) technique and the mean differences were adjudged by Duncan's Multiple Range Test (DMRT) using the statistical computer package program, MSTAT-C (Russell, 1986).

Results and Discussion

Effect of different fungicides on germination of lentil seeds

Effect of different fungicides as seed treatment on lentil seed germination was differed significantly among the treatments (Table 1). The highest germination (73.33%) at 5 days after sowing (DAS) was found where the seeds were treated with Bavistin DF followed by Deconil M-45 (71.11%) and Antracol (68.56%), and the lowest germination (40.00%) was found in control pots. Maximum germination (100%) of lentil seed was noticed at 10 DAS, where the highest germination was found where the seeds were treated with Antracol followed by Dithane M-45 (93.33%) and Secure (93.33%), and lowest germination (48.89%) was found in control. At 15 DAS data were also recorded and found no difference on increased seed germination with few exception in control. The germination was found to be increased by treating seeds with Antracol (95.66%) followed by Dithane M-45 (82.61%) and Secure (82.61%). The finding of the present study has been supported by Jayale *et al.* (2015) who reported that seed treated with Antracol, Mancozeb and Deconil increased seed germination of chick pea under pot culture condition.

Table 1. Effect of different fungicides on germination of lentil

Treatments	Germination (%)		
	5DAS	10DAS	15DAS
Provax-200	60.00 c	86.67 b	86.67 b (+69.6)
Bavistin DF	73.33 a	86.67 b	86.67 b (+69.6)
Dithane M-45	66.67 bc	93.33 ab	93.33 ab (+82.6)
Secure	60.00 c	93.33 ab	93.33 ab (+82.6)
Antracol 70WP	68.56 b	100.0 a	100.0 a (+95.7)
Deconil	71.11 ab	88.89 b	88.89 b (+73.9)
Control	40.00 d	48.89 c	51.11 c

Means having common letter(s) within a column do not differ significantly; Data in parenthesis indicate % increase (+) of germination over control; DAS: Days After Sowing.

Effect of different fungicides on seedling mortality of lentil

The lowest seedling mortality (25.09%) at harvest was found in Deconil followed by Secure (33.33%) and the highest seedling mortality (69.64%) was noticed in control (Table 2). It has been observed that the highest reduction of seedling mortality was found by treating seeds with Deconil (63.97%) followed by Secure (52.14%) over control. Hoque*et al.* (2014) carried out an experiment to test the efficacy of four fungicides in controlling foot and root rot of lentil caused by *Sclerotium rolfsii* under field condition and recorded highest performance with Secure 600WG (0.2%) in controlling the incidence of the disease. Therefore, seed treatment with Deconil and Secure might be considered for controlling root rot disease and reducing seedling mortality in lentil.

Table 2. Effect of different fungicides on seedling mortality of lentil

Treatments	Seedling mortality (%)			
	10DAS	20DAS	30DAS	At harvest
Provax-200	7.723 c	18.01 bc	18.01 c	38.40 bc (-44.9)
Bavistin DF	12.67 b	20.60 bc	28.33 b	46.15 b (-33.7)
Dithane M-45	0.00 d	16.67 bc	23.81 bc	42.86 bc (-38.5)
Secure	11.90 bc	16.67 bc	21.43 bc	33.33 cd (-52.1)
Antracol 70WP	0.00 d	24.44 b	26.67 b	44.44 bc (-36.2)
Deconil	0.00 d	12.45 c	17.40 c	25.09 d (-63.9)
Control	41.07 a	47.62 a	60.71 a	69.6 a

Means having common letter(s) within a column do not differ significantly;
Data in parenthesis indicate % decrease (-) of seedling mortality over control; DAS: Days After Sowing.

Effect of different fungicides on plant stand of lentil

Effect of different fungicides on plant stand of lentil in inoculated pot soil by *S. rolfsii* was evaluated (Table 3). The highest plant stand (74.91%) at harvest was found when the seeds were treated with Deconil followed by Secure (66.67%). It has also been found that plant stand was increased up to 146.74% and 119.60% by treating seeds with Deconil and Secure, respectively. The finding of the present study has been supported by Morshed *et al.* (2014) who reported that seed treated with Secure 600WG and Bavistin increased plant stand of lentil by 28.56% and 27.97%, respectively over control.

Table 3. Effect of different fungicides on plant stand of lentil in pot soilinoculatedwith *S. rolfsii*

Treatments	Plant stand (%)			
	20DAS	35DAS	50DAS	At harvest
Provax-200	81.99 ab	81.99 a	74.27 ab	61.60 bc (+102.9)
Bavistin DF	79.40 ab	71.67 b	63.95 bc	53.85 c (+77.5)
Dithane M-45	83.33 ab	71.43 b	66.67 bc	57.14 bc (+88.2)
Secure	83.33 ab	78.57 ab	78.57 a	66.67 ab (+119.6)
Antracol 70WP	75.56 b	73.33 ab	62.22 c	55.56 bc (+83.0)
Deconil	87.55 a	82.60 a	80.04 a	74.91 a (+146.7)
Control	52.38 c	39.29 c	34.52 d	30.36 d

Means having common letter(s) within a column do not differ significantly;
Data in parenthesis indicate % increase (+) of plant stand over control; DAS: Days After Sowing.

Effect of different fungicides on different growth parameters of lentil

The highest shoot length (32.23 cm), root length (15.20 cm) and plant height (47.43 cm) were found when seeds were treated with Bavistin DF followed by Secure where shoot length, root length and plant height were 31.47 cm, 12.33 cm and 43.50 cm, respectively (Table 4). Highest fresh weight of biomass (3.66 g/plant) was found in Antracol. Seeds treated with Bavistin DF increased shoot length, root length and plant height by 28.41%, 47.14% and 33.87%, respectively. It has also been observed that seeds treated with Antracol resulted highest increase of fresh weight of biomass/plant up to 39.3% over control. This is in accordance with the findings of Hoque *et al.* (2014) where seeds of lentil treated with secure resulted highest plant height (32.8 cm). Thakur *et al.* (2004) reported that Bavistinat rate of 0.3% gave the highest shoot length in chick pea. The effect of fungicides on number of branches/plant was quite similar except Bavistin where branches was lowest (2.67) and the highest branches/plant (4.67) was recorded in Provax-200. The highest pods/plant (58.67) and the highest healthy pods/plant (45.33) were found when the seeds were treated with Bavistin DF. On the other hand, lowest no. of infected pods/plant (4.33) and highest 100 seed weight (3.67 g) with 60% moisture level was noticed when seeds were treated with Deconil (Table 5). This is in agreement with the findings of Shahiduzzaman (2015) who found seeds of lentil treatment with Bavistin resulted highest number of pods/plant over control. Hoque *et al.* (2014) found that seeds of lentil treated with secure gave the highest 100 seed weight (1.81 g) over control.

Table 4. Effect of different fungicides on different growth parameters of lentil

Treatments	Shoot length (cm)	Root length (cm)	Plant height (cm)	Fresh weight of biomass (gplant^{-1})
Provax-200	27.27 ab (+8.65)	10.70 b (+3.58)	37.97 bc (+7.17)	2.91 b (+10.8)
Bavistin DF	32.23 a (+28.41)	15.20 a (+47.14)	47.43 a (+33.87)	2.55 b (- 2.8)
Dithane M-45	27.93 ab (+11.27)	11.67 ab (+12.97)	39.60 bc (+11.77)	2.69 b (+2.7)
Secure	31.47 a (+25.38)	12.33 ab (+19.36)	43.80 ab (+23.62)	2.66 b (+1.5)
Antracol 70WP	27.27 ab (+8.65)	10.47 b (+1.35)	36.40 bc (+2.74)	3.66 a (+39.3)
Deconil	29.97 ab (+19.40)	12.33 ab (+19.36)	42.30 abc (+19.39)	2.59 b (-1.1)
Control	25.10 b	10.33 b	35.43 c	2.63 b

Means having common letter(s) within a column do not differ significantly;
Data in parenthesis indicate % increase (+) over control.

Table 5.Effect of different fungicides on yield contributing characters of lentil

Treatments	No. of branches plant^{-1}	No. of pods plant^{-1}	No. of healthy pods plant^{-1}	No. of infected pods plant^{-1}	100-seed wt. (g)
Provax-200	4.67 a	40.33 d	31.67 b	8.66 cd	3.57 ab
Bavistin DF	2.67 b	58.67 a	45.33 a	13.33 bc	3.53ab
Dithane M-45	3.33ab	47.33 c	33.33 b	14.00 b	3.50 b
Secure	4.33ab	46.00 c	30.67 b	15.33 b	3.27 c
Antracol 70WP	3.33ab	31.33 e	24.00 c	7.33 d	3.33 c
Deconil	3.00ab	35.33 de	31.00 b	4.33 d	3.67 a
Control	4.67 a	33 e	4.67 d	28.33 a	3.30 c

Means having common letter(s) within a columndo not differ significantly.

Conclusion

From the above discussion, it can be concluded that Deconil and Secure are the best performing fungicides to control foot and root rot of lentil as well as for reducing seedling mortality. On the other hand, Bavistin DF might be suggested for enhanced plant growth and getting increased number of healthy pods in lentil.

References

Ahmed, H.U. 1985. Disease problems of pulse and oil seed crops in Bangladesh. A paper presented in the 1st National Phytopathology Conference. BARI, Gazipur. pp. 18.

Aw-Hassan, A. and Shideed, K. 2003. Economic Impact of International and National Lentil Improvement Research in Developing Countries. pp. 275-292.

Bakr, M.A. 1993. Plant Protection of Lentil in Bangladesh in Proceedings of the *Seminar on Lentil in South Asia*, 11-15 March, 1991, New Delhi, India. pp. 177-186.

BBS (Bangladesh Bureau of Statistics), 2016.Yearbook of Agricultural Statistics-2015 (27th series), p. 97.

DeVay, J.E. 2001. Seedling Diseases. Pages 13-14 in: Compendium of Cotton Diseases. T.L. Kirkpatrick and C.S. Rothrock, eds. American Phytopathological Society, St. Paul, MN

Fakir, G.A. 1983. Status of research on pulse disease at BAU. Department of Plant Pathology, BAU, Mymensingh. p. 20.

FAO, 2016. Food outlook. Biannual Report on Global Food Market. pp. 64-67.

Hoque, M.A., Hamim, I., Haque, M.R., Ali, M.A. andAshrafuzzaman, M. 2014. Effect of some fungicides on foot and root rot of lentil. Universal J. Plant Sci. 2(2): 52-56.

Jayale, S.T., Khare U.K. and Nemade, P.W. 2015. Studies on collar rot of chickpea caused by *Sclerotium rolfsii*Sacc. In: Compendium of 2nd International Conference on Biosecure and Stress Management. ANGRAU & PJTSAU, Hyderabad 7-10 January, 2015.

Kaiser, W. J.1992.Fungi associated with the seeds of commercial lentils from the U.S. Pacific North West. Plant Dis. 76: 605-610.

Morshed, M.G., Kashem, M.A., Hossain, I., Rafi, M.Y. and Latif, M.A. 2014. Effect of fungicides in controlling root rot (*Fusariumsolani*) of chick pea. Life Sci. J. 11(2): 99-102.

Navas-Cortes, J.A., Hau, B. and Jimenez-Diaz, R.M. 2000. Yield loss in chickpea in relation to development of *Fusarium* wilt epidemics. Phytopathol. 90: 1269-1279.

Punja, Z.K. 2005. The biology, ecology, and control of *Sclerotium rolfsii*, Ann. Rev. Phytopathol. 23: 97-127.

Russell, D.F. 1986. MSTAT-C computer package programme. Crop and Soil Science Department, Michigan State University, USA.

Shahiduzzaman, M. 2015.Efficacy of fungicides and botanicals in controlling foot and root rot of lentil. Bangladesh J.Agril. Res.40(4): 711-715.

Tewari, A.K. and Mukhopadhyay, A.N. 2003. Management of chickpea root rot and collar rot by integration of biological and chemical seed treatment. Indian Phytopathol. 56(1):51-52.

Thakur, K.S., Keshry, P.K., Tamrakar, D.K. and Sinha, A.K. 2004. Studies of management of collar rot disease (*Sclerotium rolfsii*) of chickpea by use of fungicides. Advan. Plant Sci. 17(2): 553-555.

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Short Communication

ROLE OF MORPHOPHYSIOLOGICAL ATTRIBUTES ON YIELD IN ONION

M. M. A. Mondal

Abstract

A field experiment was conducted under sub-tropical condition to investigate morpho-physiological characters, yield attributes and yield in ten exotic and two local onion genotypes *viz.*, AV-15142, AV-17070, AV-21844, AV-21848, J-315, J-368, J-420, JM-315, JM-368, JM-420, BARI Piaz-2 and BARI Piaz-3. Results revealed high yielding genotypes produced higher bulb yield through taller plants, higher number of leaves plant^{-1}, thicker diameter of pseudostem and larger bulb compared to low yielding ones. In contrast, low yielding genotypes produced lower bulb yield through shorter plants, fewer and shorter leaves. The genotypes AV-21844 and AV-21848 showed superiority in respect of yield contributing characters which resulting the higher bulb yield. AV-21844 also showed attractive yellow colour bulb with good keeping quality. In contrast, JM-315 showed the lowest value in case of yield contributing characters which resulting lower bulb yield though J-315 matured earliest (112 DAT) than the others.

Onion (*Allium cepa* L.) is one of the important popular spice and vegetable crops in the world (FAO, 2015). The green leaves, immature and mature bulbs are used for vegetables and spice as well. It is an important bulb crop throughout the world and is commercially cultivated in more than hundred countries. Onions in the diet play a vital role in preventing heart diseases and other ailments (Ram *et al.*, 2011). Onion is known to contain substances with antibiotic properties (Agusti, 1990).

In general, the productivity of onion is lower in the tropical countries compared to that of the temperate regions because of short duration of the winter season. As a tropical country, the yield of onion in Bangladesh is lower even than the other tropical countries due to lack of high yielding cultivar. Now, the main strategy for development of onion in Bangladesh should be to develop lines having high yield potentials with long shelf life and high levels of resistance to major diseases. At the same time, it is urgently needed to build up a large germplasm base of short-day onions through selection and hybridization. In the past, many trials were conducted in Bangladesh with long-day type (temperate) cultivars of onion. It was concluded that although many of the exotic cultivars of the temperate origin produce large bulbs in our climate, their storage potentials are very poor (Rahman, 1998). Hussain (1985) suggested that onion scientists should carry out researches on short-day type

Crop Physiology Division, Bangladesh Institute of nuclear Agriculture, BAU Campus, Mymensingh-2202, Bangladesh

onion cultivars of the tropical origin. In this regard, Bangladesh Institute of Nuclear Agriculture (BINA) has collected some exotic lines of onion from AVRDC and Japan which have tropical characteristics i.e. those line have high yield potentials with short maturity period. These exotic lines need to be assessed for their morphological and physiological traits. Therefore, this study was undertaken to assess the performances of ten exotic onion lines along with two local improved varieties on the basis of morpho-physiological features and yield attributes.

The experiment was carried out at the Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, during the period from 02 October 2014 to 26 March 2015. Ten exotic lines along with 2 local varieties were collected from AVRDC, Japan and Bangladesh Agricultural Research Institute (BARI), Bangladesh were used in this study. The name of the exotic lines/local cultivars with their sources are given in Table 1. The experiment was laid out in a Randomized Complete Block Design with 3 replications. The size of the unit plot was 2.0 m × 1.5 m. Forty-day old, healthy seedlings were uprooted carefully for transplanting in the experimental plots on 12 November 2014. Plant to plant and row to row distance were maintained at 10 cm and 20 cm, respectively. After one week of transplanting, gap filling was done where necessary.

Table 1. Source of collection and some morphological characters of ten exotic and two local genotypes of onion

Genotypes	Origin/sources	Plant height (cm)	Leaves plant^{-1} (no.)	Leaf length (cm)	Leaf breadth (cm)	Neck diameter (cm)
AV-15142	AVRDC, Taiwan	72.4 bc	8.73 c	55.3 bc	1.57 a	1.99 bc
AV-17070	AVRDC, Taiwan	68.7 cd	9.00 c	52.1 d	1.32 bcd	1.78 c
AV-21844	AVRDC, Taiwan	71.1 bc	9.80 bc	56.4 b	1.18 cd	1.92 bc
AV-21848	AVRDC, Taiwan	70.9 bc	9.73 bc	56.3 b	1.33 bcd	1.90 bc
J-315	Japan	63.7 de	9.53 bc	43.8 e	1.39 abc	1.82 bc
J-368	Japan	76.7 b	9.47 bc	56.8 b	1.27 bcd	1.99 bc
J-420	Japan	88.5 a	13.3 a	61.1 a	1.38 a-d	2.33 a
JM-315	Japan	41.0 g	8.07 d	29.0 g	0.87 f	1.15 d
JM-368	Japan	56.0 f	6.83 e	39.2 f	0.95 ef	1.22 d
JM-420	Japan	76.1 b	10.8 b	52.9 cd	1.43 ab	1.78 c
BARI Piaz-2	BARI, Bangladesh	60.3 ef	12.9 a	41.2 ef	1.19 cd	2.15 ab
BARI Piaz-3	BARI, Bangladesh	55.9 f	8.87 c	44.0 e	1.15 de	1.89 bc
F-test		**	**	**	**	**
CV (%)		5.57	9.76	3.25	9.74	9.41

In a column same figure(s) do not differ significantly at $P \leq 0.05$; **, Significant at 1% level of probability

Fertilizers were applied at the rate of N-60 kg, 36 kg, K-100 kg and S-27kg ha-1 in the form of urea, triple super phosphate (TSP), muriate of potash (MoP) and gypsum were used as source of nitrogen, phosphorus, potassium and sulphur, respectively (BARC, 2012).

Cowdung was also applied at the rate of 8 t ha^{-1}. Total amount of cowdung, TSP, MP and gypsum and half urea were applied as basal doses during final land preparation. The rest half urea was applied as top dress at 31 days after sowing. The crop was irrigated soon after transplanting and thereafter at an interval of 3 weeks. Weeding was done twice at 20 and 60 days after transplanting. To control leaf blotch, fungicide (Dithane-M 45) was applied two times at an interval of 10 days at 80 days after transplanting. Leaf chlorophyll was determined following the method of Yoshida *et al*. (1976). The date of harvest was determined when 80% leaves were fallen over. Before harvesting the plots, 10 plants were randomly selected from each plot for collecting data on morphological and yield contributing characters. The plots were harvested separately and tagged and brought to the threshing floor. The tops of onion were removed by cutting the leaves 2.5 cm away from the bulb. The collected data were analyzed statistically.

Large variation was observed in morphological characters such as plant height (range 41.0-88.5 cm), number of leaves plant^{-1} (range 6.83-13.3), leaf length (range 29.0-61.1cm), leaf breadth (range 0.87-1.57 cm) and neck diameter (range 1.15-2.33 cm) (Table 1). The genotype, J-420 had the tallest plant (85.5 cm), producing highest number of leaves plant^{-1} (13.3), thicker pseudo stem (2.33 cm) with larger leaf size. In contrast, the shortest plant (41.0 cm) with less number of leaves (6.83) as well as shortest leaf length (29.0 cm) was observed in JM-315. The genotypes having greater number of leaves with longer and broader leaves, in general, showed higher bulb weight plant^{-1} except J-420. On the other hand, low yielding genotypes had lower number of leaves as well as shorter leaf length and breadth which producing lower bulb weight plant^{-1} indicating insufficiency in source leaf in low yielding genotypes. Ananthan and Balakrishnamoorthy (2007) studied morpho-physiological parameters of 62 onion genotypes and reported that there had been a wide variation in plant height, number of leaves plant^{-1} and leaf size that supported the present experimental results.

The effect of genotypes on chlorophyll content in leaf was significant (Table 2). Results indicated that high yielding genotypes of onion possessed more chlorophyll content in leaf than in low yielding ones. The higher chlorophyll was recorded in four genotypes *viz*., AV-21844, AV-21848, BARI Piaz-2 and BARI Piaz-3 with being the highest in AV-21848 (2.16 mg g^{-1}fw). Genotypic variation in chlorophyll content of leaf in onion was also observed by Singh *et al.* (2004).

Results revealed that 8 genotypes out of 12 were damaged 100% of two months after harvest due to fungal infection indicating these genotypes had poor storage quality. The bulb damage range of other 4 genotypes was 20.0-63.6%. The lowest bulb damage was recorded in AV-21844 (20.0%) followed by AV-15142 (45.0%). Result indicated that in general, large size bulb was affected by fungus first (earlier) than small size bulb indicating poor keeping quality present in large size bulb of onion. Rabbani *et al.* (1986) observed that larger bulb sized onion genotypes had poor keeping quality than small bulb sized local ones that supported the present experimental results.

Table 2. Some plant characters of twelve exotic and local genotypes of onion

Genotypes	Chlorophyll (mg g^{-1}fw)	Rotten bulb number (%)	Bulblet generation from bulb (%)	Days to maturity	Bulb colour
AV-15142	1.87 bc	45.0 c	20.0 e	126 c	Red
AV-17070	1.77 c	63.6 b	10.5 f	126 c	Red
AV-21844	2.14 a	20.0 d	0.00 g	126 c	Yellow
AV-21848	2.16 a	57.9 b	7.90 f	130 abc	Pale yellow
J-315	1.66 c	100 a	92.4 a	135 a	Red
J-368	1.85 bc	100 a	90.7 a	128 bc	Whitish
J-420	1.80 c	100 a	18.3 e	129 bc	Red
JM-315	1.66 c	100 a	0.00 g	112 d	Red
JM-368	1.82 c	100 a	40.0 d	116 d	Red
JM-420	1.78 c	100 a	92.1 a	132 ab	Red
BARI Piaz-2	1.93 ab	100 a	56.2 b	115 d	Red
BARI Piaz-3	2.09 ab	100 a	46.7 c	115 d	Red
F-test	**	**	**	**	**
CV (%)	7.47	4.99	7.95	2.57	7.95

In a column same figure(s) do not differ significantly at $P \leq 0.05$; †: Data was collected two months after harvest.

Only two genotypes (AV-21844 and JM-315) had no splitting bulb whereas other genotypes had more or less splitting tendency. The higher splitting bulb was recorded in J-315, J-368 and JM-420 (range 90.7-92.4 %). Similarly, AV-21844, AV-21844 and JM-315 produced no bulblet and other genotypes produced more or less bulblets plant^{-1}. The highest number of bulblets plant^{-1} was recorded in JM-420 (3.66). AV-21848, J-315 and JM-420 required longer days to maturity (130-135 days after transplanting) with being the highest in J-315 (135 days after transplanting). On the other hand, JM-315 required the lowest days to maturity (112 days) followed by BARI Piaz-2 (115 days), BARI Piaz-3 (115 days) and JM-368 (116 days with same statistical rank. Most of the genotypes showed red colour bulb (Table 2). Among the studied genotypes, only J-368 had the distinct identifying character of whitish bulb colour which could be an aid in the identification of developed onion genotypes. AV-21848 had also pale yellow bulb colour which can be easily separate from the others.

The genotype, JM-420 produced the highest number of bulblets plant^{-1} (3.66) followed by J-368 (2.45) and showed significantly different with each other (Table 3). In contrast, four genotypes viz. AV-21844, AV-21848, J-315 and JM-315 produced no bulblet i.e. single bulb plant^{-1} was present in those genotypes. The fewer number of bulblets plant^{-1} was produced in AV-17070 (0.20) and AV-15142 (0.40). Genotypic variation in bulblet number plant^{-1} was also observed by Kale *et al*. (2015) in onion. Bulb diameter, the most important yield attribute, showed significant differences among the genotypes (Table 3). The genotypes which produced larger bulb also showed higher bulb yield. The genotypes AV-21844 and AV-21848 produced large size bulb (diameter 6.41 and 6.33 cm, respectively) and bulb weight (103.2 and 99.7 g bulb^{-1}, respectively) which resulted higher bulb yield (34.1 and 32.7 t ha^{-1}, respectively). In contrast, low yielding genotypes had smaller size bulb which resulted lower bulb yield. Among the low yielding genotypes, JM-

315 produced the lowest bulb yield (6.60 t ha^{-1}) due to production of smaller size bulb. Result revealed that in general, bulb-pseudostem ratio was higher in high yielding genotypes compared to low yielding ones. The highest bulb yield was recorded in AV-21844 (34.1 t ha^{-1}) followed by AV-21848 (32.7 t ha^{-1}) with same statistical rank (Table 3). The bulb yield was higher in those genotypes because of producing larger bulb. The lowest bulb yield was recorded in JM-315 (6.60 t ha^{-1}) due to production of smaller size bulbs. BARI (2003) studied with some promising onion lines and reported that high yielding genotypes had larger bulb size than lower yielding ones that supported the present results.

Table 3. Yield contributing characters and yield of ten exotic and two local genotypes of onion

Genotypes	Bulb lets plant^{-1} (no.)	Bulb diameter (cm)	Bulb pseudostem ratio	Individual bulb weight (g)	Fresh bulb yield (t ha^{-1})
AV-15142	0.40 ef	6.11 a	3.07 b	74.2 bc	24.5 bc
AV-17070	0.20 fg	6.01 a	3.38 a	78.2 b	25.8 b
AV-21844	0.00 g	6.41 a	3.34 a	103.2 a	34.1 a
AV-21848	0.00 g	6.33 a	3.33 a	99.7 a	32.7 a
J-315	0.00 g	3.63 d	1.99 d	38.4 f	12.7 f
J-368	2.45 b	4.37 c	2.20 d	67.1 d	22.1 c
J-420	0.45 e	3.87 cd	1.66 e	49.6 e	16.4 de
JM-315	0.00 g	3.42 d	2.97 b	20.0 g	6.60 g
JM-368	2.00 c	3.70 d	3.03 b	43.0 f	14.2 ef
JM-420	3.66 a	3.71 d	2.08 d	53.8 e	17.8 d
BARI Piaz-2	1.15 d	5.43 b	2.53 c	70.0 cd	23.1 c
BARI Piaz-3	1.30 d	5.32 b	2.81 b	54.0 e	17.8 d
F-test	**	**	**	**	**
CV (%)	12.51	6.51	3.35	5.47	6.94

In a column same figure (s) do not differ significantly at $P \leq 0.05$; **, Significant at 1% level of probability

Finally, among the genotypes, AV-21844 and AV-21848 performed good in respect of morphological, yield attributes and yield with AV-21844 being the best. The genotype AV-21844 may be release for commercial cultivation after few more field trials.

References

Agusti, K.T. 1990. Therapeutic and medicinal values of onions and garlic. In: Onions and Allied Crops. Vol. III, J.L. Brewster and H.D. Rabinowitch (ed.), CRC press, Boca Raton, Florida, USA. p. 63-70.

Ananthan, M. and Balakrishnamoorthy, G. 2007. Genetic variability and correlation studies in onion for economic dry matter yield. Agric. Sci. Digest, 27 (3): 190 – 193.

BARC. 2012. Fertilizer Recommendation Guide. Bangladesh Agricultural Research Council (BARC), Farmgate, Dhaka-1215. p. 34.

BARI. 2003. Evaluation for yield and yield attributes of advanced onion genotypes. Annual Report of 2002-2003. Bangladesh Agric. Res. Inst. (BARI), Gazipur 1701. p. 147.

BBS (Bangladesh Bureau of Statistics). 2015. Monthly Statistical Book of Bangladesh. February 2017. Ministry of Planning, Govt. Peoples Rep. Bangladesh. p. 114.

FAO (Food and Agriculture Organization). 2015. Production Year Book of 2003. No. 65. Published by FAO, Rome, Italy. p. 54.

Kale, S.M., Ajjappalavara, P.S., Utagi., S., Patil, H.B. and Muthal, K.M. 2015. Genetic variability for horticultural and nutritional traits in onion (*Allium cepa* L.). Eco. Env. Cons. 21: 311-317

Rabbani, M.G., Hussain, A., Siddique, M.A. and Faruque, A.H.M. 1986. Yield and storability of seven onion cultivars. Bangladesh J. Agric. 11: 1-7.

Rahman, M.H. 1998. Studies on the yield potentials of tropical onion cultivars. M.S Thsis, Dept. Hort., Bangladesh Agric. Univ., Mymensingh.

Ram, R.B., Bharti, N., Meena, M.L., Lata, R. and Babu, M. 2011. Genetic Variability and Correlation Studies in Onion (*Allium cepa* L.). *Vegetos* 24: 152-156.

Rasende, G.M., Goulart, A.C.P. and Silva, R.A. 1996. Yield characteristics of onion cultivars during summer cultivation. Hort. Brasileira 14: 151-154.

Singh, S., Yadav, P.K. and Singh, B. 2004. Effect of nitrogen and potassium on growth and yield of onion. Haryana J. Hort. Sci. 33: 308-309.

Yoshida, S., Forno, D.A., Cock, J.A. and Gomes, K.A. 1976. Laboratory manual for physiological studies of rice. 3rd ed., IRRI, Los Banos, Philippines.