SAARC J. Agri., 15(1): 189-197 (2017) *DOI: http://dx.doi.org/10.3329/sja.v15i1.33165*

Short Communication

INFLUENCE OF RESIDUAL LIME AND PLANT GROWTH REGULATOR (NAA) ON THE MORPHOLOGICAL AND PHYSIO-CHEMICAL TRAITS OF AROMATIC RICE CV. KATARIBHOG

M.S. Rahman[1*], B.C. Sarker[1], M. Akhter[2], M.A. Bashar[1] and M.R. Islam[3]

[1]Department of Agricultural Chemistry, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh
[2]Bangladesh Agricultural Research Institute, Joydebpur, Gazipur, Bangladesh
[3]Department of Crop Physiology and Ecology, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh

Aromatic rice possess high potential to draw attention rice consumer of the world for its aroma, fragrance, grain morphology, quality and other desirable traits. The production of aromatic fine rice is profitable due to its prices up to 10 times more than common rice on international market (Chaudary et al., 2001). In Bangladesh, a number of fine rice cultivars are grown by the farmers specially Kataribhog, Chinisagar, Badshabhog, Kalizira, Tulsimala, Dulabhog, Basmati, Banglamoti (BRRI dhan50), BRRI dhan34, BRRI dhan37 and BRRI dhan38. Liming is a normal agronomic practice to manage acid sulfate soils for crop production. In Malaysia, some areas of acid sulfate soils have been reclaimed for rice cultivation using lime. In the acid sulfate soils of the Muda Agricultural Development Authority (MADA) granary areas in Kedah-Perlis coastal plains (northwest coast of Peninsular Malaysia), for instance, rice yield improved significantly after applying 2.5 tons of ground magnesium limestone (GML) ha^{-1}. However, over liming may reduce crop yields due to lime induced P and micronutrient deficiencies (Fageria, 1984). Plant growth regulators (PGRs) are organic compounds, other than nutrients that modify plant physiological processes and also called biostimulants or bioinhibitors that act inside plant cells to stimulate or inhibit specific enzymes or enzyme systems and thus regulate plant metabolism. Recently, there has been global realization of the important role of PGRs in agriculture for better growth and yield of crop (Prasad and Paudel, 1994). These (PGRs) are being used as an aid to enhance yield. Naphthalene Acetic Acid (NAA) is one of the growth promoting hormones, which may play significant role to change growth characters and yield in BRRI dhan28.

---

[*] Corresponding author email: sagor_hstu@yahoo.com

Received: 26.10.2016

The PGRs play vital roles in coordination of many growth and behavioral processes in rice, which regulates the amount, type and direction of plant growth (Anjum et al., 2011). The use PGRs, as NAA, GA_3 or their compounds, is becoming popular to ensure efficient production. Remarkable accomplishments of PGRs such as manipulating plant growth and crop yield have been actualized in recent years (Morinaka et al., 2006; Zvi and Eduardo, 2011). The PGRs modify growth and development in various ways under different growth conditions. NAA and GA3 is responsible for stimulating the production of mRNA molecules in the cells, which in turn improves the chances of fast growth (Olszewki and Gubler, 2002; Emongor, 2007). Recently, the scientists of Bangladesh are being advised to use PGRs to get higher rice production. But the research on examining the combination effect of NAA and lime application in acid piedmont soil for better rice yield is still in initial stage. Yield is the cumulative effect of a variety with its inherent characteristics, management practices and the environment in which it is grown. Variety is one of the most important factors for increasing yield. Thus a study was undertaken with the objectives of identifying the suitable dose of NAA in order to achieve both quantitative and qualitative effect on aromatic rice production. Work on NAA with lime is limited to improve the rice yield in Northwest Bangladesh. Studies in other countries of the world although provides useful information, that cannot be recommended or practiced without trial in our local condition. Therefore, more researches or trials are necessary to investigate the efficacy of NAA on aromatic rice. Thus, the present study was carried out - i) to study the effect of NAA and residual lime effect on growth characteristics of Kataribhog. ii) to know the flag leaf composition of aromatic rice and the yield of Kataribhog.

The study was conducted at agricultural farm, Department of Agricultural Chemistry, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur during February to May, 2011. The rice variety Kataribhog rice was used as a test plant. Lime were applied (see modification in abstract) @ T_1 = 0 t ha^{-1} (Control), T_2 = 1.0 t ha^{-1}, T_3 = 1.5 t ha^{-1}, T_4 = 2 t ha^{-1}, T_5 = 2.5 t ha^{-1} used in previous crop at summer mungbean cv. BARImung-7.Treatment @ H_0 = 0 ppm NAA (Control), H_1 = 100 ppm NAA, H_2 = 150 ppm NAA and H_3 = 200 ppm NAA spraying at vegetative and pre-flowering stages while water was used as control (H_0). The experiment was laid out in a randomized complete block design with three replications. Thirty five days old seedlings were transplanted in February, 2012 using three seedlings hill^{-1}. Recommended dose of triple super phosphate (180 kg ha^{-1}), muriate of potash (100 kg ha^{-1}), gypsum (20 kg ha^{-1}) and zinc (7.5 kg ha^{-1}) were incorporated to soil at final land preparation. Urea (215 kg ha^{-1}) was applied in three equal splits at 20, 35 and 55 DAT. Data on yield and yield contributing parameters, plant height, flag leaf length, flag leaf width, leaf numbers plant^{-1}, tiller numbers hill^{-1} were recorded at maturity, while the panicle numbers hill^{-1}, filled grains panicle^{-1}, unfilled grains panicle^{-1}, 1000-grain weight, grain length, grain width, grain yield ha^{-1}, straw yield ha^{-1}, harvest index were recorded after harvest (synchronized all parameter). Chemical compositions of flag leaves under different treatments using PGR in the lime tested plots were estimated. The K, Ca, Mg, Zn, Cu and Fe content of flag leaves were estimated as per standard methods. Leaf chlorophyll-a, chlorophyll-b and total carotenoid were also monitored from green flag leaves. The data were statistically analyzed to compare treatment means using the MSTATC computer software developed, (Russell, 1986). If the treatments were significant the differences between pairs of means were compared by LSD followed by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

Plant height (cm) at maturity stage in table 1 indicated that combined effect of different levels of plant growth regulator (PGR) and residual lime had significant stimulatory effect. Maximum height (138.70 cm) was obtained from the application of both 2 t ha^{-1} residual lime and 100 ppm NAA while shortest plant (107.00) cm was recorded from T1 × H_2 and T_2 × H_0 treatments respectively. It seems to be due to intact cells elongation. Watanabe and Saigusa, 2004 stated that plant height was significantly increased by the application of 50 ppm ethephon, 100 ppm GA_3 alone or in combination over that of control. The number of tillers is one of the most important factors for yield. Tiller production especially the number of effective tillers is the potential factor for yield component. Both the number of tillers and effective tillers $hill^{-1}$ was significantly increased with the concentrations of 100 ppm NAA and 2 t ha^{-1} residual limes. The highest number of tillers and effective tillers $hill^{-1}$ were 14.67 and 12.00 respectively while the lowest tiller numbers and effective tillers (10.00) were recorded from 200 ppm NAA and no residual lime application (Table 1). Similar trend was reported through Miyodo application by (Islam, 2007). Leaf numbers, flag leaf length and flag leaf breadth are the most important growth characters of plant on which crop yield depends. The number of leaves was highest at maximum tillering stage of growth and decreased thereafter (Islam, 2008). The decreased in leaf number at later stages of growth might be due to senescence or drying up of leaves. Maximum number of leaves (7.00) was obtained from 100 ppm NAA with 1.5 t ha^{-1} residual lime application. Both NAA and residual lime markedly increased flag leaf length and breadth (Table 1). Plant hormones play important role in regulating the leaf numbers and leaf area (Liu et al., 2012).

The panicle length and number of filled grains $panicle^{-1}$ as well as number of unfilled grains $panicle^{-1}$ are very important parameters to evaluate the yield performance of a variety in response to a specific treatment. Table 2 showed that the highest values of panicle length, filled grains $panicle^{-1}$, unfilled grains $panicle^{-1}$, grain yield and straw yield (28.00 cm, 139.30, 39.67, 1.63 t $ha^{-1}$and 7.00 t ha^{-1} respectively) where as the lowest values of panicle length, filled grains $panicle^{-1}$, unfilled grains $panicle^{-1}$, grain yield and straw yield (18.00 cm, 105.7, 18.00, 0.80 t $ha^{-1}$and 4.25 t ha^{-1}, respectively). Panicle length, filled grains and grain yield differed significantly and increased by the application of both PGR and lime (Table 2). Maximum grain yield was observed due to application of 100 ppm NAA and 2 t ha^{-1} residual effect of lime

Table 1. Effect of PGR and residual lime on morphological and growth characters of Kataribhog rice

Treatments	Plant height (cm)	Tiller numbers	Effective tiller numbers	Leaf numbers	Flag leaf length (cm)	Flag leaf width (cm)
$T_1{\times}H_0$	130.70d	11.33ef	9.00de	5.33d	30.17cd	1.06a
$T_1{\times}H_1$	131.70c	12.67cd	10.67bc	6.67ab	29.80cde	1.03a
$T_1{\times}H_2$	107.00n	10.33hi	7.67g	6.00c	35.67a	0.96a
$T_1{\times}H_3$	107.70m	10.00i	6.67i	6.00c	27.83f	1.00a
$T_2{\times}H_0$	107.00n	10.67gh	7.67g	6.67ab	27.33f	0.93a
$T_2{\times}H_1$	135.00b	12.67cd	9.00de	6.33bc	30.00cde	1.10a
$T_2{\times}H_2$	120.30i	11.33ef	7.67g	6.33bc	30.27c	1.16a
$T_2{\times}H_3$	113.00j	12.33d	9.00de	6.67ab	23.33h	0.83a
$T_3{\times}H_0$	110.70k	10.33hi	7.67g	6.67ab	29.67cde	1.16a
$T_3{\times}H_1$	129.30e	13.67b	10.33c	7.00a	33.33b	1.10a
$T_3{\times}H_2$	129.00e	13.00c	11.67a	6.33bc	32.57b	1.16a
$T_3{\times}H_3$	121.70h	12.33d	9.00de	6.33bc	29.17de	1.03a
$T_4{\times}H_0$	126.30g	11.00fg	7.67g	6.67ab	27.33f	1.00a
$T_4{\times}H_1$	138.70a	14.67a	12.00a	6.67ab	29.83cde	1.13a
$T_4{\times}H_2$	131.90c	14.00b	11.00b	6.33bc	26.93f	1.06a
$T_4{\times}H_3$	131.70c	11.67e	8.33f	6.67ab	30.33c	0.90a
$T_5{\times}H_0$	107.70m	11.67e	7.00hi	6.00c	30.27c	1.16a
$T_5{\times}H_1$	127.70f	11.67e	7.33gh	6.33bc	30.00cde	1.00a
$T_5{\times}H_2$	109.30l	12.67cd	8.67ef	6.67ab	25.23g	1.03a
$T_5{\times}H_3$	128.00f	12.33d	9.33d	6.67ab	29.00e	1.13a
LSD (5%)	0.5	.35	.33	0.3	0.20	0.17

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

Here, T_1 = 0 t ha^{-1} (Control), T_2 = 1.0 t ha^{-1}, T_3 = 1.5 t ha^{-1}, T_4 = 2 t ha^{-1}, T_5 = 2.5 t ha^{-1} and H_0 = 0 ppm NAA (Control), H_1 = 100 ppm NAA, H_2 = 150 ppm NAA, H_3 = 200 ppm NAA

application. (Gurmani et al., 2006), they stated that ABA, BA and CCC plant growth regulators increased grain yield of rice. The finding is also similar with Pandey et al., 2001, whom reported that IAA @ 50 ppm produced significantly maximum grain yield plant^{-1}, 1000-grain weight and yield kg ha^{-1}. The present result also agrees with the findings of previous studies (Andreevska et al., 2004; Islam et al., 2008). Harvest index is the ratio of economic yield and biological yield, and the ultimate partitioning of dry matter between grain and vegetative parts is indicated by

HI, the economic yield of rice is its grain, biological yield of a crop is the TDM at final harvest (Davald and Hamblin, 1976). Table 2 showed that, the highest percentage of Harvest Index (HI) was found at $T_3 \times H_1$ (21.22%) and lowest was at $T_2 \times H_2$ (13.07%). This result confirmed the results of previous studies (Islam, 2007; Islam et al., 2008).

Table 2. Effect of PGR and residual lime on yield attributes and yields of Kataribhog rice

Treatments	Panicle length (cm)	Filled grain panicle^{-1}	Unfilled grain panicle^{-1}	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
$T_1 \times H_0$	23.33ghi	129.00f	24.33f	0.89cd	7.17a	18.06e
$T_1 \times H_1$	24.30ef	134.30d	35.00b	1.46abc	5.87bc	19.92bc
$T_1 \times H_2$	19.00l	118.00k	21.67i	1.38abcd	6.92a	16.63g
$T_1 \times H_3$	18.00m	121.00j	25.67e	0.94bcd	4.25f	18.11de
$T_2 \times H_0$	22.00k	116.70l	25.33e	0.80d	4.92e	13.99i
$T_2 \times H_1$	27.00b	138.30b	21.33ij	1.43abc	6.25b	18.62d
$T_2 \times H_2$	25.67c	122.00i	32.00c	0.94bcd	6.25b	13.07j
$T_2 \times H_3$	23.00hij	137.70b	20.67j	1.38abcd	5.68bc	19.55bc
$T_3 \times H_0$	22.67ijk	125.00h	23.33gh	0.88cd	5.68bc	13.41j
$T_3 \times H_1$	26.00c	130.30e	24.33f	1.53ab	5.68bc	21.22a
$T_3 \times H_2$	25.33cd	138.00b	30.33d	1.44abc	6.92a	17.22f
$T_3 \times H_3$	23.33ghi	128.00g	23.00h	1.40abcd	5.68bc	19.77bc
$T_4 \times H_0$	27.67ab	102.30o	18.00l	1.38abcd	5.50cd	20.06b
$T_4 \times H_1$	27.00b	139.30a	18.33kl	1.63a	6.15b	20.95a
$T_4 \times H_2$	28.00a	136.70c	21.67i	1.13abcd	5.68bc	16.59g
$T_4 \times H_3$	25.33cd	122.00i	39.67a	1.40abcd	5.68bc	19.77bc
$T_5 \times H_0$	24.67de	121.30ij	19.00k	1.37abcd	6.25b	19.35c
$T_5 \times H_1$	22.33jk	110.30m	22.67h	1.08abcd	5.00de	17.76e
$T_5 \times H_2$	23.67fgh	105.70n	24.00fg	1.13abcd	5.68bc	16.59g
$T_5 \times H_3$	24.00efg	128.30fg	32.33c	1.29abcd	7.00a	15.56h
LSD (5%)	0.90	1.30	2.67	0.30	0.60	0.52

Mean followed by same letter do not differ significantly at 5% level

Chlorophylls are the most widely distributed plant pigments responsible for the characteristic green color of fruit and vegetables (Almela, 2000). A significant variation was found in chlorophyll-a, chlorophyll-b, total chlorophyll and total caroteinoid content through combined effect of PGR and lime (Table 3). The highest amount of chlorophyll-a content of flag leaf was observed in $T_4 \times H_1$ (20.60 mg g^{-1} FW) followed by $T_1 \times H_1$ (20.32 mg g^{-1} FW) and $T_4 \times H_3$ (20.13 mg g^{-1} FW) combination while the lowest chlorophyll-a content of flag leaf was observed in $T_4 \times H_2$ (16.49 mg g^{-1} FW). The highest value of chlorophyll-b content were found in both $T_2 \times H_2$ and $T_4 \times H_1$ (11.78 mg g^{-1} FW) and while the lowest chlorophyll-b content was found in $T_5 \times H_1$ (5.69 mg g^{-1} FW). The highest total chlorophyll was obtained in $T_4 \times H_1$ (32.38 mg g^{-1} FW) followed by $T_1 \times H_1$ (31.40 mg g^{-1} FW) while the lowest total chlorophyll content was happen in $T_5 \times H_1$ (24.12 mg g^{-1} FW) treatment combination (Table 3). The highest mean value of total carotenoid content was found in $T_4 \times H_0$ (2.15 mg g^{-1} FW) while the lowest carotenoid content was obtained in $T_5 \times H_2$ (0.76 mg g^{-1} FW).

Table 3. Effect of PGR and residual lime on Chlorophyll content (mg g^{-1}) in flag leaf of Kataribhog rice

Treatments	Chlorophyll-a	Chlorophyll-b	Total Chlorophyll	Total carotenoid
$T_1 \times H_0$	17.45f	9.26gh	26.71j	1.89abc
$T_1 \times H_1$	20.32a	11.08bc	31.40b	1.41bcde
$T_1 \times H_2$	19.34bc	11.54ab	30.88bcd	1.18def
$T_1 \times H_3$	17.42fg	9.92ef	27.34i	1.17def
$T_2 \times H_0$	20.58a	10.69cd	31.27bc	1.48bcde
$T_2 \times H_1$	19.39bc	10.61cd	30.00e	1.50bcde
$T_2 \times H_2$	17.99ef	11.78a	29.77e	1.10ef
$T_2 \times H_3$	16.86h	9.08h	25.94k	1.28def
$T_3 \times H_0$	19.06bc	9.72efg	28.78f	1.49bcde
$T_3 \times H_1$	19.52b	11.32ab	30.84bcd	1.73abcd
$T_3 \times H_2$	17.50f	7.30i	24.80l	2.01ab
$T_3 \times H_3$	19.39bc	11.27ab	30.66d	0.96ef
$T_4 \times H_0$	18.82cd	7.10i	25.92k	2.15a
$T_4 \times H_1$	20.60a	11.78a	32.00a	0.91ef
$T_4 \times H_2$	16.49h	9.56fgh	26.05k	0.96ef
$T_4 \times H_3$	20.13a	10.61cd	30.74cd	1.27def
$T_5 \times H_0$	18.50de	9.07h	27.57hi	1.50bcde
$T_5 \times H_1$	18.43de	5.69j	24.12m	0.98ef
$T_5 \times H_2$	16.90 gh	11.36ab	28.26fg	0.76f
$T_5 \times H_3$	17.80f	10.15de	27.95gh	1.29cdef
LSD (5%)	0.52	0.41	0.21	0.30

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

Table 4 showed there is no significant variation in K content in flag leaves. The highest K content were found in $T_2 \times H_3$ and $T_4 \times H_3$ (0.59 mg l^{-1}) while the lowest was obtained in $T_1 \times H_3$ (0.47 mg l^{-1}). The residual effect of 2 ton ha^{-1} lime along with 200 ppm NAA helps to uptake highest rate of K in flag leaves. The status of K improved the rice straw quality. The variation of K content in different varieties was variable (Sarwar et al., 2010).A significant variation was found in flag leaves Ca content in relation to application of various levels of residual lime and NAA (Table 4). Maximum Ca content was found in $T_3 \times H_1$ (131 mg l^{-1}) while the lowest was found in $T_1 \times H_3$ (100 mg l^{-1}). This result revealed that 100 ppm NAA may have positive impact on Ca content in rice leaf. Secondary nutrient plays important roles in

Table 4. Effect of PGR and residual lime on leaf nutrient composition (mg g^{-1}) in flag leaf of Kataribhog rice

Treatments	K	Ca	Mg	Zn	Cu	Fe
$T_1 \times H_0$	0.50	111g	22.20k	0.15	0.18	2.56a
$T_1 \times H_1$	0.57	113f	29.20de	0.14	0.24	2.04abc
$T_1 \times H_2$	0.57	106j	29.00e	0.09	0.26	2.02abc
$T_1 \times H_3$	0.47	100n	20.70l	0.02	0.17	1.08e
$T_2 \times H_0$	0.48	108h	21.00l	0.16	0.17	1.97abc
$T_2 \times H_1$	0.56	115d	22.50k	0.14	0.19	1.87bc
$T_2 \times H_2$	0.53	102m	25.60h	0.09	0.24	1.69bcd
$T_2 \times H_3$	0.59	100n	25.60h	0.05	0.15	1.97abc
$T_3 \times H_0$	0.46	106j	25.50h	0.05	0.21	1.71bcd
$T_3 \times H_1$	0.58	131a	33.60a	0.27	0.26	2.49a
$T_3 \times H_2$	0.57	124b	31.10b	0.18	0.34	2.29ab
$T_3 \times H_3$	0.51	120c	29.60d	0.14	0.31	2.54a
$T_4 \times H_0$	0.56	106j	29.55d	0.03	0.23	1.83bc
$T_4 \times H_1$	0.57	114e	31.50b	0.14	0.20	1.88bc
$T_4 \times H_2$	0.53	107i	28.10f	0.32	0.12	1.47cde
$T_4 \times H_3$	0.59	103l	23.40j	0.02	0.16	1.21de
$T_5 \times H_0$	0.52	104k	24.70 i	0.16	0.07	1.07e
$T_5 \times H_1$	0.55	103l	26.50g	0.15	0.13	1.44cde
$T_5 \times H_2$	0.57	108h	26.80g	0.03	0.12	1.79bcd
$T_5 \times H_3$	0.50	115d	30.50c	0.21	0.14	2.22ab
LSD (5%)	ns	2.00	0.30	ns	ns	0.38

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

plant life. Calcium is an essential part of cell structure and plays its role in cell division (Tandon, 2000). The total Mg uptake differed significantly with respect to application of different levels of lime and PGR applied in combination (Table 4). The highest Mg content was recorded in $T_3 \times H_1$ (33.60 mg l^{-1}) followed by $T_4 \times H_1$ (31.1 mg l^{-1}). On the other hand, the lowest was recorded in $T_1 \times H_3$ (20.70mg l^{-1}). Magnesium is an integral part of chlorophyll and thus, linked with photosynthesis. It plays an important role in energy transfer processes in plants (Tandon, 2000).

There is no significant variation in Zn and iron content in flag leaves (Table 4). Similar result was obtained by (Tomasevei and Anicic, 2010). The iron content of the flag leaf of Kataribhog rice cultivar also showed a significant variation in relation to NAA and residual effect of lime (Table 2). The highest amount of flag leaf iron content was found in $T_1 \times H_0$ (2.56 mg l^{-1}) followed by $T_3 \times H_3$ (2.54 mg l^{-1}) treatments. On the other hand, the lowest was found in $T_5 \times H_0$ (1.07 mg l^{-1}).

From the above findings, it can be concluded that Napthalene Acetic Acid and residual effect of lime significantly affected the yield as well as yield contributing parameters of Kataribhog rice, especially at 100 ppm NAA and 2 t ha^{-1} of lime application.

REFERENCES

Almela, L., Fernandez-Lopez, J.A. and Roca., M.J. 2000. High-performance liquid chromatographic screening of chlorophyll derivatives produced during fruit storage. *Journal of Chromatography*, 870: 483-489

Andreevska, D., Spasenoski, M. and Ilieva, V. 2004. Effect of naphthalene acetic acid (NAA) on the morphological-production properties and the yield at rice (*Oryza sativa* L.). In: Proceeding 2nd congress of ecologists of the Republic of Macedonia with international participation, 25-29

Anjum, S.A., Wang, L.C., Farooq, M., Hussain, M., Xue, L.L. and Zou, C.M. 2011. Brassinolide application improves the drought tolerance in maize through modulation of enzymatic antioxidants and leaf gas exchange. *Journal of Agronomy and Crop Science*, 197:177-185

Chaudhary, R.C., Tran, D.V., Duffy, R.R. and Nations, F.A.O.U. 2011. Specialty rices of the world: breeding production and marketing. Food and Agricultural Organization (FAO) Rome in association with Science Publishers Inc., P.O. Box 699, Enfield, New Hampshire 03748, USA. 358 pp

Emongor, V. 2007. Gibberellic acid (GA3) influence on vegetative growth, nodulation and yield of cowpea (*Vigna unguiculata* L). *Journal of Agronomy*, 6:509-517

Fageria, N. K. 1994. Soil acidity affects availability of nitrogen, phosphorns, and potassium. *Better Crops International*, 10:8-9

Gomez, K.A. and Gomez, A.A. 1984. Statistical procedures for Agricultural Research. (2nd Eds.) John Wiley and Sons, New York, 640

Gurmani, A.R., Bano, A. and Salim, M. 2006. Effect of growth regulators on growth, yield and ions accumulation of rice (*oryza sativa* L.) under salt stress. *Pakistan Journal of Botany*, 38(5): 1415-1424

Islam, M. M., Mondal, M. A., Ali, M. M., Akther, Q. Y., Begum, M. Z. F. A. and Prodhan, A. K. M. A. 2008. Effect of foliar application of GABA and Miyodo growth regulators on yield and yield attributes in wheat. *Journal of Agroforestry and Environment*, 2(1): 131-135

Islam, M. Z. 2007. Effect of Miyodo on growth and yield of *boro* rice (BRRI dhan-29). M. S. Thesis, Department Crop Botany, Bangladesh Agricultural University, Mymensingh

Liu, Y., Chen, W., Ding, Y., Wang, Q., Li, G., Want, S. 2012. Effect of Gibberellic acid (GA_3) and α-naphthalene acetic acid (NAA) on the growth of unproductive tillers and the grain yield of rice (*Oryza sativa* L.). *African Journal of Agricultural Research*, 7(4): 534-539

Morinaka, Y., Yoshiaki, I., Masakazu, A., Hidemi, K., Motoyuki, A. and Makoto, M. 2006. Morphological alteration caused by Brassinosteroid insensitivity increases the biomass and grain production of rice. *Plant Physiology*, 141:924-931

Olszewki, S.N.T. and Gubler, F. 2002. Gibberellins signaling: biosynthesis, catabolism and response pathways. *Plant Cell*, 14:S61-80

Pandey, A.K.R.S.,Tripathi and R.S.Yadav. 2000. Effect of certain growth regulators on growth yield and quality of rice (*Oryza sativa* L.). *Indian Journal of Agricultural Research*, 35 (2):118-120

Russel, D.F. 1986. MSTATC Package Programme. *Crop and Soil Sci. Dept*. Michigan State University, USA

Sarwar, M., Khan, M.A. and Iqbal, Z. 2002. Feed resources for livestock in Pakistan. *International Journal of Agriculture and Biology*, 4: 186–192

Tandon, P.K. 2000. Zinc, Iron and phosphorus interaction on some growth attributes in rice under pot culture conditions. *Journal of Research*, Assam Agricultural University, 5(1): 34-43

Watanbe, H., Saigusa, M. and Hase, S. 2004. Cloning of a cDNA encoding an ETR2-like protein (Os-ERL1) from deep water rice (*oryza sativa* L.) and increase in its mRNA level by submergence, ethylene, and gibberellins treatments. *Journal of Experimental Botany*, 55: 1145-1148