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GROWTH AND YIELD RESPONSES OF BROCCOLI VARIETIES UNDER COASTAL SALINE AREA OF BANGLADESH

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AUTHORS' CONTRIBUTIONS

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The field experiment on broccoli (*Brassica oleracea* var. Italica L.) was conducted at Bangladesh Agricultural Research Institute, On-Farm Research Division, Dawlatpur, Khulna during the season 2021-2022 taking five varieties, namely BARI Broccoli-1, Green Crown, Green Giant, Green Carpet, PARATSO to investigate the salt-tolerant varieties for maximizing broccoli yield as well as farmers' income. The experiment was laid out randomized complete block design with three replications. Among the five varieties the maximum curd diameter (19.00 cm), curd length (16.50 cm) and curd weight (486.67 g) were recorded from V_4 (Green Carpet). The yield range of the varieties was 13.65 to 19.46 t ha^{-1}. Variety V_4 (Green Carpet) was produced the maximum yield (19.46 t ha^{-1}) followed by V_2 (Green Crown) was (18.12 t ha^{-1}). Since the V_4 (Green Carpet) and V_2 (Green Crown) are suitable for the coastal areas, if this variety is combined with the coastal area cropping pattern then the cropping intensity will increase, which will be beneficial to the farmers economically and meet the nutritional also.

Keywords: Broccoli variety; soil salinity; tolerance; coastal area; growth and yield performance.

1. INTRODUCTION

The human population is currently above seven billion and is expected to increase to nine billion in 2050. To provide a robust food supply for this growing population, agricultural productivity must increase concomitantly [1]. In the current context of anthropogenic global warming, various abiotic stresses frequently occur in the environment which significantly retard crop production [2]. Soil salinity is one of the most important determinants of agricultural production, and irrigation with saline water affects the

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growth of plants through its influence on many plant metabolic processes [3]. More than 833 million hectares around the globe (8.7% of the planet) have been affected by salinity and lost revenues per annum US $27.3 billion [4]. In Bangladesh, about 20% of total lands, and over 30% of the cultivable lands have been covered by the coastal zone. The coastal area of Bangladesh includes 16 districts, and the major salt-affected areas are Shatkhira, Khulna, Patuakhali, and Borguna [5].

Micronutrient-rich vegetables, such as broccoli has been extensively popular because of its nutritional benefits and medicinal value [6]. This winter cultivated crop has abundant vitamins, minerals, carotenoids, ascorbic acid, thiamin, riboflavin, niacin, calcium, iron, fiber, and antioxidant that are preventive against cancer [7]. Being originated from West Europe, broccoli has been expanded from temperate to both the sub-tropical and tropical regions that include Bangladesh [8]. In Bangladesh, broccoli has been cultivated in limited areas (about 10.5 metric tons per hectare) with a minimum production only [9].

Being a moderately salt-sensitive crop with an estimated threshold ECe of 2.8 dS m^{-1} and a slope of 9.2%, broccoli has been facing deleterious effect on germination; shoot, and root length; and plant growth that resulted in yield reduction in salinity conditions [10]. In coastal Bangladesh, during the dry season, the salt accumulation rises, hence the production of winter vegetables like broccoli gets affected due to the presence of higher soluble salt in soil [11]. As broccoli is winter grown vegetable, the growth and production have significantly been reduced by salinity stress [12].

Nowadays, salinity is one of the major concerns in agriculture that leads to some negative impacts on crop productivity and yield growth [13]. Although broccoli is a nutritious vegetable, no significant research has been done for the salinity effect on the growth, development, and yield of broccoli varieties in Bangladesh. Therefore, it has been greatly important to determine the effect of varying degrees of salinity on the broccoli life cycle to promote its production in the coastal regions of Bangladesh [11]. Thus, this research might be helpful for selecting or breeding the varieties to provide economical yield under saline conditions that might be an efficient tool for minimizing salinity problems. As a consequence, this investigation is focused on the growth and yield responses of Broccoli varieties by the influence of salinity conditions in Bangladesh.

2. MATERIALS AND METHODS

This experiment was conducted from 08 November 2020 to 25 February 2021 in the experimental field of Bangladesh Agricultural Research Institute, On-Farm Research Division, Dawlatpur, Khulna. The location of the experimental site was at the High Ganges River Flood Plain (22.8875 N latitude and 89.5167 E longitudes). The soil of the experimental field was Silt loam-Clay of dark grey soil color. The soil contained pH of 6.8 and organic matter 2.1%. The experiment consists of four genotypes, namely BARI Broccoli-1, Green Crown, Green Giant, Green Carpet and PARATSO. Green Crown, Green Giant, Green Carpet and PARATSO were collected from the market of Dhaka and BARI Broccoli-1 was collected from Bangladesh Agricultural Research Institute, Gazipur. The field experiment was laid out in a factorial Randomized Complete Block Design with three replications. The unit plot size was 4m x 1.5m accommodating 24 seedlings/plot. The land was fertilized with nitrogen, phosphorous, potassium and molybdenum as cowdung, urea, TSP, MOP and molybdenum @ 1500, 210, 120, 100 and 1kg/ha, respectively. The entire amount of cowdung, TSP, MOP and molybdenum were applied at the time of final land preparation and the entire urea was applied as top dressing in two equal splited at 15 and 30 days after transplanting (DAP). Seeds were treated by provax @ 2 g/kg seed. Treated seeds were sown in the seedbed on 09 October 2020. Healthy 30 days old seedlings were transplanted on 08 November 2020. Weeding was done 6 times to keep the plots free from weeds and the soil was mulched by breaking the soil crust for easy aeration and conservation of soil moisture. The plots were irrigated four times at regular intervals during the growing season to keep the field moist for better growth and development of plants. Five broccoli plants from each plot were selected randomly for collecting data. The plants of the outer rows and the extreme end of the middle rows were excluded from data collection. Data on plant height (cm), number of leaves/plant, fresh weight of leaves/plant (g), fresh weight of stem/plant (g), fresh weight of root/plant (g), days to curd initiation, curd diameter (cm), curd length (cm), curd weight/plant (g), primary curd dry matter (g), number of lateral branch/plant and lateral branch weight/plant (g) were recorded. Plot yield was converted to per hectare yield (t/ha). The soil salinity of the experimental plots was recorded every 15 days interval from planting to harvesting of the crop (Fig. 1). Soil salinity was varied from 3.6 to 6.4 dS/m. Collected data were statistically analyzed by Software R (version 4.1.2). Mean separation was done by LSD at 5% level of significance.

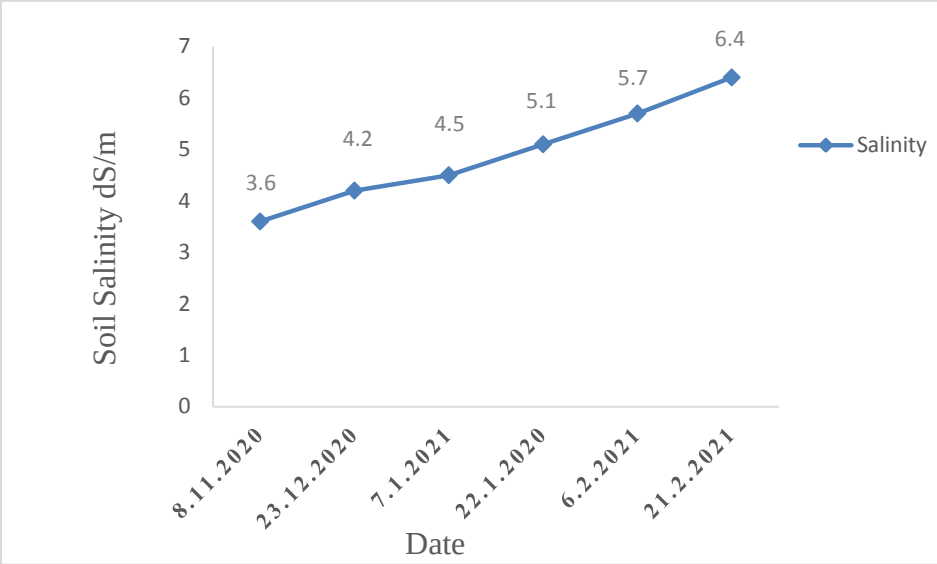

Fig. 1. Soil salinity during crop growing period

Table 1. Monthly average air temperature, total rainfall and total rainy days during the experimental period from June 2020 to May 2021 in Khulna given below

Month	Weekly rainfall (mm)				Monthly rainfall (mm)	Temperature °C (monthly average)	
	1st week	2nd week	3rd week	4th week		Max.	Min.
Jun-20	51	2	13	15	81	36.2	34.1
Jul-20	89	110	20	110	329	37.6	35.4
Aug-20	258	70	210	52	590	36.1	35.2
Sep-20	104	145	50	41	340	33.4	30.6
Oct-20	68	45	18	99	230	32.3	28.8
Nov-20	0	44.1	0	0.3	44.4	26.02	19.86
Dec-20	0	0	0	0.3	0.3	21.38	16.13
Jan-21	0.3	0	0.3	0.6	1.2	20.56	15.48
Feb-21	0.9	0	0.3	0.3	1.5	22.56	16.66
Mar-21	0	0	0	0	0	29.45	22.10
Apr-21	0	0	9	16	25	32.5	31.4
May-21	0	64	10	15	89	34.6	32.5

3. RESULTS AND DISCUSSION

In plant height, the effect of salinity was found to be significant with the salt concentration. In this observation, the highest reduction of plant height was found in V_2 (31.11 cm) which was statistically similar with V_1 (31.26 cm) and V_4 (32.67 cm). Whereas, the lowest growth reduction was observed in V_5 (32.97 cm) which was statistically similar with V_3 (33.54 cm). The result was found similar in the previous research findings of Mwazi [14] who reported that when saline water concentration increases, the plant growth rate decreases with an Inverse relationship between salinity concentration and growth rate.

Results presented in the (Table 2) indicated that significant changes of leaf number was observed for the salt stress. The maximum number of leaves/plant is observed in V_4 (70.00) while the minimum number of leaves/plant is found in V_1(16.33) which was statistically similar with V_3(16.67). Similar findings were observed in the research of Muries et al., [15].

There were significant differences among the varieties of fresh weight of leaves, stem and root (Table 2). Whereas maximum leaf weight was found from V_2 (1125.67 g) which was statistically similar with V_4 (1026.67 g) and V_5 (900.00 g) whereas minimum from V_1 (732.33 g) which was statistically similar with V_3 (733.33), V_4 (1026.67 g) and V_5 (900.00 g). More or less similar findings were found from Rahman et al., [16] where the fresh weight of leaves varied 395.56 g to 830.77g between the ranges of soil salinity 2.6 to 4.8 dS/m. In the case of the stem, Maximum weight

loss was observed in V_1 (177.67 g) variety of broccoli which was statistically similar with V_3 (246.67 g). On the other hand, the degree of reduction of stem fresh weight was less for V_5 (366.67 g) variety of broccoli which was statistically identical with V_4 (360.00 g) and V_2 (295.33g). These results have been confirmed by the results of Zaghdoud et al., [17] in broccoli. Maximum fresh root weight was observed in V_2 (56.00 g) variety of broccoli which was statistically similar with V_5 (53.33 g) and V_4 (46.67 g) while minimum root weight was (35.33 g) for V_1 which was statistically similar with V_3 (40.67 g) and V_4 (46.67 g). The findings of this study are similar to those of Shannon & Grieve [18]. Netondo et al., [19] reported that salinity increases concentrations of Na^+ and Cl^- ionic toxicity may have affected decreases in the osmotic potential, root hydraulic conductance, and stomatal conductance water uptake as a result water deficit in the plant leading to decrease net photosynthesis. Water deficit may as well occur as the result of lowered water potential of the soil solution and restricting root water uptake. Reduction in dry weight of plant tissues reflects the increased metabolic energy cost and reduced carbon gain, which are associated with salt adaptation which in turn may have affected reduce the biomass of leaves, stem and proper root growth. Neumann [20] indicated that salinity can rapidly inhibit the root growth and its capacity to water uptake and essential mineral nutrition from the soil.

Minimum 52.33 days from transplanting to first visible curd was found from V_3 which was statistically similar with V_4 (53.0 DAP) and V_5 (52.4 DAP) whereas maximum days required for curd initiation from V_2 (59.00 DAP) which was statistically similar with V_1 (58.33 DAP). Rahman et al., [16] also reported the variation of days to curd initiation from 64 to 84 DAP among 4 different varieties.

Table 2. Impact of soil salinity on growth parameters of broccoli varieties

Variety	Plant height (cm)	Number of leaves/plant	Fresh weight of leaves/plant (g)	Days to curd initiation	Fresh weight of stem/plant (g)	Fresh weight of root/plant (g)
V_1	31.26 b	16.33 d	732.33 b	58.33 ab	177.67 c	35.33 b
V_2	31.11 b	42.33 c	1125.67 a	59.00 a	295.33 a	56.00 a
V_3	33.54 a	16.67 d	733.33 b	52.33 c	246.67 bc	40.67 b
V_4	32.67 b	70.00 a	1026.67 ab	53.67 c	360.00 a	46.67 ab
V_5	32.97 a	56.67 b	900.00 ab	55.33 c	366.67 a	53.33 a
Lsd	1.68	10.51	296.80	3.01	83.86	12.20
CV (%)	2..77	13.68	17.44	2.87	15.39	13.97

V_1=BARI Broccoli-1, V_2= Green Crown, V_3=Green Giant, V_4=Green Carpet, V_5=PARATSO

Plate 1. Pictorial view of different broccoli varieties during the study period

The effect of various salinity concentrations was observed in yield parameters of curd diameter, curd length, curd weight/plant, primary curd dry matter, number of lateral branch/plant, total Secondary curd weight/plant.

The genotypes differed significantly at final harvest from one another in respect curd diameter, curd length, curd weight/plant and curd yield (t/ha) (Table 3). In this experiment the maximum diameter of curd (19.00 cm) was obtained from the variety V_4 which was statistically similar with V_1 (17.00 cm), V_2 (16.33 cm) and V_5 (16.50 cm) and the minimum diameter of curd was found 15.00 cm from V_3 which was statistically similar with V_1 (17.00 cm), V_2 (16.33 cm) and V_5 (16.50 cm). The maximum curd length was 16.67 from V_2 which was statistically similar with V_4(16.50 cm) and V_5(15.16 cm) and the minimum curd length was 13.67 from V_1 which was statistically similar with V_3 (14.00 cm) and V_5 (15.16). The highest (486.67g) curd weight was recorded from V_4 which was statistically similar with V_1(341.33 g), V_2 (453.00 g) and V_5 (420.00 g) and the lowest (319.67g) weight of V_3 which was statistically similar with V_1(341.33 g), V_2 (453.00 g) and V_5 (420.00 g). In the case of curd yield, different varieties display marked variation (Table 2). V_4 (Green Carpet) yielded (19.46 t ha^{-1}) maximum which was closely related to V_2 (Green Crown) (18.12 t ha^{-1}). Minimum yield was recorded from V_3 (Green Caint) (20.98 t ha^{-1}), which was statistically parallel to V_1 (BARI Broccoli-1) (13.65 t ha^{-1}). The results in previous work showed similar results of Giuffrida et al., [21] in broccoli. They reported that salinity significantly modified broccoli head unit weight, diameter and length were similarly affected by salinity with a significant decrease compared to the control. broccoli head diameter, length and yield were similarly affected by salinity with a significant decrease at 40 mM L^{-1} NaCl and the yield decreased by about 20% at 20 mM L^{-1} of NaCl. Curd yield depends on the intensity of salinity level and tolerance potential of the broccoli varieties [22]. However, salinity reduces photosynthesis by reducing rubisco enzyme activity, CO_2 uptake, stomatal conductance and nutrients uptake of the plants [23,24].

The result indicated that the highest primary curd dry matter was measured from V_4 (18.04 g) and it was statistically identical with V_5 (16.03 g). On the other hand, the lowest primary curd dry matter was measured from V_3 (11.96 g). These findings are similar to the previous research of [25]. Salinity increases the carbohydrate, starch and nonstructural carbohydrate content in leaves and increases carbohydrate content in leaves and decreases curd dry matter production which suggest that salinity inhibits the carbohydrate translocation to the tuber [26,22].

A Varietal difference existed with respect to the number of secondary curd/plant and total Secondary curd weight/plant. The maximum number of lateral curd/plant was found from V_4 (9.00) which was statistically identical with V_5 (8.33) whereas minimum from V_3 (1.33). The highest total Secondary curd weight/plant was found from V_5 (299.33 g) while the lowest lateral branch weight /plant from V_3 (71.33 g) was statistically identical with V_2 (114.67g) and V_4 (117.67g). The findings were also supported by Islam et al., [27]. They observed that the above findings were not in conformity with the result of this finding. But it is partially confirmed that the variety affects significantly on the number of branches $plant^{-1}$. Laila [28] find out significant results among the varieties where the highest number of branch $plant^{-1}$ was found in SR-03 (5.20) and the lowest was SR-08 (2.92).

Table 3. Impact of soil salinity on yield parameters of broccoli varieties

Variety	Curd diameter (cm)	Curd length (cm)	Curd weight/ plant (g)	Total yield (t ha^{-1})	Primary curd dry matter (g)	Number of secondary curd/plant	Total Secondary curd weight/plant (g)
V_1	17.00 ab	13.67 c	341.33 ab	13.65 ab	15.39 b	4.33 b	159.33 b
V_2	16.33 ab	16.67 a	453.00 ab	18.12 ab	15.42 b	4.67 b	114.67 bc
V_3	15.00 b	14.00 bc	319.67 b	12.78 b	11.96 c	1.33 c	71.33 c
V_4	19.00 a	16.50 ab	486.67 a	19.46 a	18.04 a	9.00 a	117.67 bc
V_5	16.50 ab	15.16 abc	420.00 ab	16.80 ab	16.03 ab	8.33 a	299.33 a
Lsd	3.73	2.56	150.30	6.01	2.61	2.35	57.75
CV (%)	11.84	8.94	19.75	19.75	9.01	22.62	20.11

V_1=BARI Broccoli-1, V_2= Green Crown, V_3=Green Giant, V_4=Green Carpet, V_5=PARATSO

4. CONCLUSION

It is therefore concluded that better production could be obtained from saline-sodic soils by the cultivation of suitable varieties tolerant to salinity and sodicity. Salt tolerance potential in different *Brassica* species addition of crop yields. Among all varieties under study V_4 (Green Carpet) and V_2 (Green Crown) produced comparable more curd yields. These results lead to conclude that V_4 (Green Carpet) and V_2 (Green Crown) may be superior and could successfully be cultivated on saline-sodic soils having an Ece=6.4 dSm^{-1} without application of any amendment.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Chevilly S, Dolz-Edo L, López-Nicolás JM, Morcillo L, Vilagrosa A, Yenush L, Mulet JM. Physiological and Molecular Characterization of the Differential Response of Broccoli (*Brassica oleracea* var. Italica) Cultivars Reveals Limiting Factors for Broccoli Tolerance to Drought Stress. Journal of Agricultural and Food Chemistry. 2021;69(35):10394-10404.
2. Onaga G, Wydra K. Advances in plant tolerance to abiotic stresses. Plant genomics. 2016;10:229-272.
3. Othman Mohamed Abdel Rahim, Iman Qassim Mohammed. Effect of organic fertilizer and foliar application of humic and salicylic acids on reducing salinity stress of irrigation water on vegetative growth characteristics of broccoli (*Brassica Oleracea*) Plant. Plant Archives. 2020;20(1):2263-2268.
4. FAO. World Map of Salt-Affected Soils Launched at Virtual Conference. Retrieved from Food and Agriculture Organization of the United Nations; 2021.
5. Hasan MH, Rahman MR, Haque A, Hossain T. Soil salinity hazard assessment in bangladesh coastal zone. In International Conference on Disaster Risk Management; 2019.
6. Roos N, Wahab MA, Chamnan C, Thilsted SH. The role of fish in food-based strategies to combat vitamin A and mineral deficiencies in developing countries. The journal of Nutrition. 2007; 137(4):1106-1109.
7. Mirdad ZM. Effect of K+ and salicylic acid on broccoli (*Brassica oleraceae* var. italica) plants grown under saline water irrigation. Journal of Agricultural Science. 2014;6(10):57-66.
8. Mohosina F. Effect of cowdung and boron on growth and yield of broccoli (*Brassica oleracea*). Journal of Bioscience and Agriculture Research. 2019;22(2):1845-1851.
9. Hafiz MA, Biswas A, Zakaria M, Hassan J, Ivy NA. Effect of planting dates on the yield of broccoli genotypes. Bangladesh Journal of Agricultural Research. 2015;40(3):465-478.
10. Wang P, Li X, Tian L, Gu Z, Yang R. Low salinity promotes the growth of broccoli sprouts by regulating hormonal homeostasis and photosynthesis. Horticulture, Environment, and Biotechnology. 2019;60(1):19-30.
11. Biswas AK, Mannan M, Dash PK. Germination, growth and yield response of Kohlrabi, Brassica oleracea var. Bioscience and Bioengineering Communications. 2016;2(1): 81-89.
12. Rios JJ, Agudelo A, Moreno DA, Carvajal M. Growing broccoli under salinity: The influence of cultivar and season on glucosinolates content. Scientia Agricola. 2020;77:20190028.
13. Majeed A, Muhammad Z. Salinity: A Major Agricultural Problem—Causes, Impacts on Crop Productivity and Management Strategies.
14. Mwazi FN. Green house evaluation of the effects of salinity on germination, growth and quality of vegetables grown in a hydroponic system along the coast of Namibia. Agricola. 2012;22:45-49.
15. Muries B, Carvajal M, Martínez-Ballesta MDC. Response of three broccoli cultivars to salt stress, in relation to water status and expression of two leaf aquaporins. Planta. 2013;237(5):1297-1310.
16. Rahman M, Rashid MH, Shahadat MK, Chowdhury AK, Akkas ali M. Effect of planting dates on performance of broccoli in coastal area of bangladesh. Bangladesh Journal of Agricultural Research. 2020;45(4):419-429.
17. Zaghdoud C, Alcaraz-Lopez C, Mota-Cadenas C, Martínez-Ballesta MDC, Moreno DA, Ferchichi A, Carvajal M. Differential responses of two broccoli (*Brassica oleracea* L. var Italica) cultivars to salinity and nutritional quality improvement. The Scientific World Journal; 2012.
18. Shannon MC, Grieve CM. Tolerance of vegetable crops to salinity. Scientia horticulturae. 1998;78(1-4):5-38.
19. Netondo GW, Onyango JC, Beck E. Sorghum and salinity. Crop Science. 2004;44(3):797-805.

20. Neumann P. Salinity resistance and plant growth revisited. Plant, Cell and Environment. 1997;20(9):1193-1198.
21. Giuffrida F, Gangi D, Giurato R, Leonardi C. Effects of NaCl salinity on yield, quality and mineral composition of broccoli and cauliflower. In VI International Symposium on Brassicas and XVIII Crucifer Genetics Workshop. 2012;1005:531-538.
22. Dahal K, Li XQ, Tai H, Creelman A, Bizimungu. Improving potato stress tolerance and tuber yield under a climate change scenario – a current overview. Frontiers in Plant Science. 2019;10:563.
23. Odemis B, Caliskan ME Photosynthetic response of potato plants to soil salinity. Turkish Journal of Agricultural and Natural Sciences. 2014;1(2):1429-1439.
24. Akhtar SS, Anderson MN, Liu F. Biochar mitigates salinity stress in potato. Journal of Agronomy and Crop Science. 2015;201(5): 368-378.
25. De Pascale S, Maggio A, Barbieri G. Soil salinization affects growth, yield and mineral composition of cauliflower and broccoli. European Journal of Agronomy. 2005;23(3): 254-264.
26. Ghosh SC, Asanuma K, Kusutani A, Toyota M. Effect of salt stress on some chemical components and yield of potato. Soil Science and Plant Nutrition. 2001;47(3):467-475.
27. Islam MN, Rahman MS, Alom MS, Akheruzzaman M .Performance of different crops productivity enhancement through adaptation of crop varieties at charland in Bangladesh. Bangladesh Journal of Agricultural Research. 2015;40(4):629-640.
28. Laila JF. Performance of rapeseed and mustard varieties with different planting techniques. MS thesis. Department of agronomy Sher-e-Bangla Agricultural University Dhaka-1207; 2014.