EFFECT OF COWDUNG, ZINC AND BORON ON GRWOTH AND YIELD OF CARROT

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CERTIFICATE

This is to certify that the thesis entitled, **"Effect of cowdung, zinc and boron management on growth and yield of carrot"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in the partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (MS) IN HORTICULTURE,** embodies the result of a piece of *bonafide* research work carried out by **Abduallha-Al-Noman,** Registration No. **09-03281** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed during the course of this investigation has been duly acknowledged and style of this thesis have been approved and recommended for submission.

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TO

MY BELOVED PARENTS

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The Author

EFFECT OF COWDUNG, ZINC AND BORON ON GRWOTH AND YIELD OF CARROT

ABSTRACT

The study was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, during the period from 8 November, 2013 to 20 February, 2014 in Rabi season. The experiment consisted of one factor viz. T_1 = CD_{15} t + Zn_0 kg + B_2, T_2 = CD_{15} t + Zn_2 kg + B_2, T_3 = CD_{15} t + Zn_4 kg + B_2, T_4 = CD_{15} t + Zn_6 kg + B_2, T_5 = CD_{15} t + Zn_4 kg + B_0, T_6 = CD_{15} t + Zn_4 kg + B_1, T_7 = CD_{15} t + Zn_4 kg + B_3, T_8 = CD_0 t + Zn_4 kg + B_2, T_9 = CD_{10} t +Zn_4 kg + B_2, T_{10} = CD_{20} t + Zn_4 kg + B_2 and T_{11} = CD_0 t + Zn_0 kg + B_0 kg/ha respectively. The experiment was laid out in RCBD with three replications. In case of cowdung, zinc and boron management, the maximum foliage length per plant (75.47 cm), fresh leaves weight per plant (232.10 g), root length (21.00 cm), root diameter (5.17 cm), percentage dry matter content of leaves (20.10), fresh weight (160.70 g), dry matter of root (12.35 %), yield per plot (6.17 kg), yield per hectare (59.67 t) was recorded from T_6 treatment and the minimum foliage length per plant (60.07 cm), fresh leaves weight per plant (181.00 g), root length (13.47 cm), diameter of root (3.60 cm), percentage dry matter content of leaves (15.30), weight of root (117.50 g), percentage dry matter content of root (8.45 %), yield per plot (2.84 kg) and yield (28.45 t/ha) were observed from T_{11} treatment. The highest benefit cost ratio (3.34) was noted from T_6 treatment and the lowest (2.08) was estimated from T_{11} treatment. From growth, yield and also economic point of view, it is apparent that T_6 treatment was suitable for carrot cultivation.

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ABBREVIATIONS AND ACRONYMS

%	:	Percentage
@	:	At the Rate of
Abstr.	:	Abstract
AEZ	:	Agro-ecological Zone
Agric.	:	Agriculture
AVRDC	:	Asian Vegetables Research and Development Center
BARC	:	Bangladesh Agricultural Research Council
BARI	:	Bangladesh Agricultural Research Institute
BAU	:	Bangladesh Agricultural University
BBS	:	Bangladesh Bureau of Statistics
BCR	:	Benefit Cost Ration
cm.	:	Centimeter
cv.	:	Cultivar
DAS	:	Day After Sowing
et al.	:	et alii (and others)
FAO	:	Food and Agriculture Organization Of the United Nations
Fig.	:	Figure
FW	:	Fresh weight
FYM	:	Farm Yard Manure
G	:	Gram
Hort.	:	Horticulture
i.e.	:	That is
J.	:	Journal

K	:	Potassium
Kg	:	Kilogram
LSD	:	Least Significant Difference
M	:	Meter
MP	:	Murate of Potash
N	:	Nitrogen
NS	:	Non-significant
^{O}C	:	Degree Celsius
P	:	Phosphorus
RCBD	:	Randomized Complete Block Design
Sci.	:	Science
Soc.	:	Society
T	:	Tonne
ton/ha	:	Ton per hectare
Tk.	:	Taka
TSP	:	Triple Super Phosphate
UK	:	United Kingdom
UNDP	:	United Nations Development Program
Viz.	:	Namely

CHAPTER I

INTRODUCTION

Carrot (*Daucus carota* L.) is one of the important vegetable crops in the world. It is a member crop of Apiaceae family (Peirce, 1987). It is considered to be a native of Mediterranem region (Shinohara, 1984). It consists of above 250 genera and approximately 2800 species of widely distributed, generally herbaceous plants (Rubatzky *et al.*, 1999). It is mainly a temperate crop grown during spring in temperate countries and during winter in tropical and subtropical countries of the world (Bose and Som, 1990). Carrot grows successfully in Bangladesh during Rabi and mid November to early December is the best time for its cultivation to get satisfactory yield (Rashid, 2004).

From nutritional point of view carrot is a very important root crop. It contains appreciable amount of carotene, thiamine and riboflavin (Sharfuddin and Siddique, 1985). It is an excellent source of iron, vitamin-A, Vitamin-B, Vitamin-C and sugar (Yawalkar, 1985). Carrot roots play an important role to protect the blindness of children providing vitamin-A. Furthermore, it has some other important medicinal values (Bose and Som, 1990). The area under carrot cultivation was 899 thousand hectares with total production of 19,374 thousand tons in the world (FAO, 2010). Rashid (2004) mentioned an average yield of carrot was 27 tons per hectare. This production is relatively low compared to other carrot producing countries like Switzerland, Denmark, Sweden, UK, Australia and Israel where the average per hectare yields are reported to be 40.88, 42.67, 51.88, 54.88, 56.70 and 64.20 tons, respectively (FAO, 2013). But, in Bangladesh the production statistics of carrot is not available.

The low yield of carrot in Bangladesh however is not an indication of low yielding potentially of this crop, but of the fact the low yield may be attributed to a number of reasons, viz. unavailability of quality seeds of high yielding varieties, fertilizer management, disease and insect infestation and improper irrigation facilities. Deficiency of soil nutrients in Bangladesh (Islam and Noor, 1982). To attain considerable production and quality yield for any crops it is necessary to proper management including ensuring the availability of essential nutrient components in proper doses. Carrot thrives well in a fertile, clay loam soil because it requires amounts of nutrients to sustain rapid growth in short time. A large amount of fertilizer is required for the growth and development of vegetable crops (Opena *et al.*, 1988).

This may be due to the unawareness of our vegetable growers about the proper management practices of the crop including complete fertilizer use. For successful carrot production, optimum doses of fertilizer play a vital role. The soils of Bangladesh are deficient in macronutrients, like nitrogen, phosphorous and potassium for which farmers are advised to use urea, TSP and MoP for carrot production. In recent year, the importance of some micronutrients has been recognized in the growth and development of plants. Unlike the major nutrients, micronutrients are required in only small quantities. Even though these elements are needed only in minute quantities, many soils fail to supply them in adequate quantities for healthy growth of plants and optimum yield (Grewal and Trehan, 1979).

Oragnic matter content of Bangladesh soil is below 1% in about 60% cultivable land as compared to an ideal minimum value of 4%. In the area of continous cropping, organic matter supply to the soil through cowdung, compost, green manure etc. are provided only to a minimum extent. On an average, well rotted cowdung contains 0.5% N, 0.2% P_2O_5 and 0.5% K_2O (Yawalkar *et al.*, 1984). Thus an average dressing on 25 tons per hectare of cowdung supples 112 kg N, 56 kg P_2O_5 and 112 kg K_2O (Guar *et al.*, 1984).

Cowdung is a source of food for the innumerable number of microorganisms and creatures like earthworm who breaks down these to micronutrients, which are easily absorbed by the plants. Cowdung plays a direct role in plant growth as a source of all necessary macro and micronutrients in available forms during mineralization, improving the physical and physiological properties of soils. Cowdung improves soil structure, texture, humus, color, microbial activity as well as increase its water holding capacity. Decreased organic matter content of soil hampers soil microbial activity. Organic manures not only influence the prospective of soil but also increase the crop yield.

Micronutrients can be obtained from both organic and inorganic sources. It can be supplied to the soil by applying inorganic fertilizers of micronutrients or compost, manure and other organic fertilizers. It is very essential for plant growth but required in a low amount.

Zinc effect on many functions of the plant such as hormone movement, active salt absorption, flowering and fruiting process, pollen germination, carbohydrates and nitrogen metabolism and water relations in the plants. The increase in vegetative growth could be attributed to physiological role of boron and its involvement of protein, synthesis of pectin, resynthesis of adenosine triphosphate (ATP) and translocation of suger at development of the flowering and fruiting stages (Bose and Tripathi, 1996). Boron deficiency causes reduced root growth, brittle leaves and necrosis of shoot apex. Zinc deficiency causes new leaves emerge white in color, older leaves may die, plant severely dwarfs (Singh and Gangwar, 1991). Boron is a micronutrient is necessary for cell division, movement of sugars through protoplasmic membranes and development of phloem and transport of certain hormones. Boron affects the cambium and phloem tissues of storage rot or stem, apical meristems of leaves, vascular cambia of other organs, which are capable of maristematic activeties. Boron stimulates carotenoid synthesis (Florescu and Cernea, 1961). Several workers stated that, the application of micronutrients in addition to essential major elements can play a good role in increasing the yield of carrot (Homutescu *et al.*, 1963; Haaz and Homa, 1969 and Balooch *et al.*, 1993).

Moreover, it facilitates aeration in soil. Therefore, judicious and proper use of organic manures as like cowdung and fertilizer is very essential not only for obtaining higher yield and quality production but also maintain soil health and sustainability for longer period. Considering the above circumstances, the present investigation was undertaken with following objectives:

i) To find out the optimum dose of cowdung, zinc and boron on the growth and yield of carrot.

ii) To determine the combined effect of zinc, boron and cowdung composition on the growth and yield of carrot as well as ensuring the higher yield.

CHAPTER II

REVIEW OF LITERATURE

Carrot is one of the important root crops of the world but in Bangladesh it is mainly used as a vegetable. Through, plants get major nutrients from the soil, they are not adequate to meet the increasing demand for higher production. In carrot growing areas of country, many soils are unable to supply the required nutrients. Hence, the micronutrients and organic manure play a specific role in the growth and development of carrot. Since the literature on the effect of cowdung, zinc and boron on growth and yield attributes is very less in carrot, the literature on other related crops is also included in this chapter for better understanding of the subject.

2.1 Effect of cowdung on growth and yield of carrot

Khadtare *et al.* (2006) conducted a field experiment in tomato and carrot at the college farm of Anand Agricultural University, Anand, during Rabi season of 2005-2006. The experiment was laid out in a RCBD with four replications. Application of 25% recommended dose of fertilizer (RDF) through FYM gave the highest marketable yield.

Akand (2003) conducted an experiment with mulching and organic manure trial on carrot in BAU, Bangladesh and observed that black polythene mulch and cowdung significantly resulted the highest yield of carrot.

Mesquita *et al.* (2002) conducted an experiment on a clayey yellow red Oxisol to evaluate the residual effect of the application of phosphorous and urban waste compost of the previous two years on the root production of carrot cv. Brasilia in Brazil. Carrot plants were harvested 90 days after planting. After the harvest a linear and quadratic effect for phosphorus and urban compost was highly significant. The maximum root production was 26.5 t/ha corresponding to 18.5 t/ha of P_2O_5 and 53.2 t/ha of urban waste compost.

Oliveira *et al.* (2001) studied the effect of cowdung and mineral fertilizer on root production in carrot and found that the different levels (0, 15, 20, 25 and 30 t/ha) of cowdung, in the presence or absence of mineral fertilizers, on the production roots was evaluated in a field experiment conducted in Areia (Praibaj), Brazil during July-October, 1997. Cowdung 25 t/ha produced the highest total (70.1 t/ha) and marketable (31.1 t/ha) yields and the lowest non-marketable yield of root (39.0 t/ha). The production of Extra-A and extra grade roots increased linearly as cowdung rates increased. Production of extra-A and extra grade roots increased by approximately 0.6 and 0.16 t/ha for each of tone of cowdung added in the soil. The presence of mineral fertilizers increased root yields and increased the production of Extra-A and Extra grade, special and first grade roots by 4.9, 5.6, 1.7 and 19.4 t/ha, respectively compared to its absence.

Salminen *et al.* (2001) showed the effect of plant growth in carrot with the application of digested poultry slaughterhouse waste as nitrogen source, gave the highest yield.

Schuch *et al.* (1999) worked on the effect of organic manure (cowdung and chicken) on yield and quality of carrot cv. ‘Nastes Forto’, ‘’Flakkese, ‘Fuyumaki’, ‘Nastes superior’, ‘Harumaki Kinko’ were studied in 1993 and 1995. In 1995, carrot cv. ‘Nastes superior’and ‘Harumaki Kinko’ were replaced by Brasillia and Tin Ton. Manure was applied at 4.5, 6.5 and 15 t/ha in 1993 followed by 2.1, 2.6 and 15 t/ha in 1995. In the 1993 experiment, ‘Nastes’ for to produce the highest root yield. Root number, weight, diameter and length varied different amount of manure applied. Application of organic manure generally increased all the parameters evaluated.

Vieira *et al.* (1998) studied on a clayey Dusky Red Latosol in Dourados, Barzil, to evaluate the response of P fertilizer application at 4.5, 25.8, 43.0, 60.2 and 81.7

kg/ha as triple supper phosphate as well as the response to application of cowdung at 1, 6, 10, 14 and 19 t/ha. The treatments were defined by the plane puebla III experimental matrix, resulting in the following p (kg/ha) and cowdung (t/ha) combination: 4.3 × 6, 25.8 × 1, 25.6 × 6, 25.8 × 14, 43.0 × 10, 60.2 × 6, 60.2 × 14, 60.2 × 19 and 81.7 × 14. Each plot was 3.5 cm^2 with 10 plants grouped in double rows. During the vegetative cycle, plant height was measured every 15 days. Harvesting was carried out 3 month after were between 31 cm (4.3 kg P/ha + 6 t cowdung/ha) and 37 cm (60.2 kg P/ha + 19 t cowdung /ha), 90 and 100 days after planting, respectively. Dry manure production of marketable root was independent of cowdung level but increased linearly with P dose ranging from 0.42 t/ha (4.3 kg P/ha) to 1.3 t/ha (81.7 kg P/ha). Marketable root yield of carrot increased linearly with P and cowdung rates, averaging 10 t/ha.

Sediyama *et al.* (1998) carried out an experiment to assess the plant nutritiontal status, root quality and yield of carrot cv. Brasilla, influenced by the following treatments: seven types of organic compounds which were produced from liquid swine manure and straw materials, crushed sugarcane, napier grass and coffee straw and crushed sugarcane with four replication from 3 May to 23 August, 1994 in Ponte Nova county, Minas Gerais State, Brazil. Generally, both a greater plant height and Arial part yield were obtained from compounds produced from coffee straw plus liquid swine manure, crushed sugarcane plus triple super phosphate and napier grass plus liquid swine manure provided yields of total roots higher than 50 t/ha. The organic compound from coffee straw and liquid swine manure provided a greater yield of total and commercial roots. Enrichment of the organic compound crushed sugarcane plus liquid swine manure with gypsum or triple super phosphate did not affect root yield, neither Ca and P contents in leaves and roots. The carrot roots that received organic or mineral fertilization presented superior P and K contents and similar Ca content, when compared to those contents considered as standard foe human diets.

Datta and Chakrabarty (1995) conducted a field experiment in 1991-1993 at srinketan, West Bengal with 0, 50 and 100 kg/ha each of N, P_2O_5 and K_2O and 10 t/ha of cowdung. The highest carrot yield (7.6 t/ha) was obtained from the highest NKP rate used. Among the cowdung, the highest root yields were obtained from 10 t/ha followed by rice husk ash. Kale *et al.* (1991) observed that use of cowdung is helpful reducing basal dose of fertilizer to 25 % in carrot. Bohec (1990) studied on the use of cowdung for carrot production in 1980-1986. Carrot were grown in rotation on land with annual application of cowdung. The highest total yield of carrot was 78.4 t/ha. Lang (1984) found that organic manures increased the yield of carrot (10-12 %) compared with control. Hochmuth and Howell (1983) reported that leaf area, leaf number, total dry weight and the highest marketable yield (18.6 t/ha) was obtained from organic cowdung raised beds with 'New Kuroda' where non-organic mulched bed gave the lowest yield (7.0 t/ha). Sans *et al.* (1974) stated that organic compound reduced soil temperature on the soil surface and depth of 10 cm soil temperature disappeared of carrot cultivation.

2.2 Effect of zinc and boron on growth and yield of carrot

Patwary *et al.* (2015) reported an experiment was conducted at the Horticulture Farm of the Bangladesh Agricultural University, Mymensingh during winter season to study the effects of fertilizer management practices on the growth and yield of carrot. The experiment consisted of six fertilizer doses, viz. (i) cowdung @ 9 t/ha, (ii) poultry manure @ 5.63 t/ha, (iii) Urea-TSP-MP @ 195-132-120 kg/ha, (iv) Urea-TSP-MP-Gypsum @ 195-132-120-89 kg/ha, (v) Urea-TSP-MP-Gypsum-Borax @ 195-132-120-89-10 kg/ha, (vi) Urea-TSP-MP-Gypsum-Borax-Zinc sulphate @ 195-132-120-89-10-20 kg/ha. Fertilizer doses had significant influence on all of the aforesaid characters along with number of leaves and root diameter. The use of Urea-TSP-MP-Gypsum-Borax-Zinc sulphate @ 195-132-120-89-10-20 kg/ha fertilizers produced maximum gross (36.41 t/ha) and marketable (33.20 t/ha) yields of carrot whereas the minimum gross (26.09 t/ha) and marketable yields (23.45 t/ha) were found from the treatment of cowdung @ 9 t/ha.

Theunissen *et al.* (2010) reported plant nutrients including N, P, K, Zn and B, the uptake of which has a positive effect on plant nutrition, photosynthesis, the chlorophyll content of the leaves and improves the nutrient content of the different plant components of carrot (roots, shoots and leaf). The high percentage of humic acids in fertilizer dose contributes to plant health, as it promotes the synthesis of phenolic compounds such as anthocyanins and flavonoids which may improve the plant quality and act as a deterrent to pest and diseases.

A three study on carrot during winter season under Nasik, India conditions revealed that the trace elements zinc, copper and boron and significant effect on root development and yield as well as root quality when applied in combination instead of singly. Foliar application of 3 ppm Zn + 1 ppm Cu + 0.5 ppm B at 30 and 45 days after transplanting gave the highest net return to the carrot growers (Bhonde *et al.*, 1995). An experiment was carried out to study the response of carrot to the application of boron fertilizer in Pakisten using 4 levels of boron (0, 1, 1.5 and 2 kg B/ha). The crop also received a basal dressing of NPK fertilizers and FYM (5 t/ha). From this experiment, Efkar *et al.* (1995) reported that generally all the fertilizer treatments increased yield over control. Application of 1.5 kg B/ha gave the highest root yield of 7.9 t/ha compared with the control yield of 7.8 t/ha. Kabir *et al.* (1994) reported that application of boron with different levels showed positive response to yield of carrot. Dwivedi and Dwivedi (1992) carried out an experiment to find out the efficacy of different metghods of application of copper, zinc and boron to carrot on an acid Inceptisol during 1986-87 at Ranichauri, Uttar Pradesh, India. It was concluded that the highest yield was obtained when boron was applied with a basal dressing. Pregno and Arour (1992) carried out a field experiment to find out boron deficiency and toxicity in carrot on an Oxisol of the Atherton tablelands at North

Queensland, Australia. It was found that root yield was the highest when 2 kg B/ha was applied and it was followed by 4 kg/ha. Kuaggio and Ramos (1986) studied the influence of micronutrient boron on the production of carrot. Boron was applied at the rates of 0, 3, 6, 9 and 12 kg/ha as boric acid. It was concluded that the effect of boron was more pronounced on the yield of large sized roots than on the small ones. A field trial was conducted by Maurya and Singh (1985) to determine the effect of zinc on growth, yield and quality of carrot. Plants were grown in mid October received di-sodium tetraborate at 0-20 kg per hectare. It was concluded that 10 kg per hectare gave the highest increased viz. 41% over the control and the best quality indices. Rasp (1985) studies the effect of added trace elements in 12 years crop rotation in which carrots and cereals were grown in alternate years. It was found that only boron tended to increase carrot yield. Alekseeva and Rasskazov (1976) studied the effect of boron on the yield and storability of carrots. It was found that the treatments increased the total yield by 6.2-13.2 % and the commercial yield by up to 6.3 %. Increases in sugar, carotene, dry matter contents were also observed. Nelyubova *et al.* (1972) conducted an experiment to find out the sensitivity of carrot to boron under different levels of nitrogen nutrient. It was concluded that the highest yield was obtained when boron was applied with a basal NPK dressing of 30:60:90 kg/ha, but when nitrogen was raised to 60 or 120 kg/ha, yield did not increase. Kevorkov (1972) carried out a pot experiment on soil poor in phosphorus, aluminum and molybdenum but with adequate boron. Mo and B were applied with NPK basal dressing with or without lime. It was observed that the effectiveness of the minor elements was greater in the unlimed soil. Yields from carrot given B + Mo (1 or 2 mg per kg soil) were higher than with either of the elements applied alone. The B + Mo treatment increased the root carotene and carbohydrate contents. Kononovich (1971) carried out an experiment to find out the effect of micro-elements on the quantity and quality of carrot yield. Carrot seeds soaked in solutions of 0.1 % boric acid or $CuSO_4$, each at 1.6 liters/4 kg seeds, showed 63 and 65 % germination, respectively, compared to 52 % in the control. The treatments also increased yield and carbohydrate and vitamin-C contents. Kanwar and malik (1970) found that micro-nutrient had no effects on root quality although boron increased the root yield of carrot when applied in combination with lower dose of NPK. Boron and calcium have related roles in plant growth of carrot. If the calcium content of the growing tissue is high, boron content should be high also. Purvis and Carolus (1964) mentioned that in case of boron deficiency in root vegetables, the root surfaces often were wrinkled and cracked. So boron is necessary for proper root development. Homutescu *et al.* (1963) studied the influence of boron and zinc on the production of carrots. Carrot of the variety Chantenay were treated with boric acid and zinc sulphate. It was concluded that boron increased the yields by 5.31 - 23.47% while zinc by 7.35-16.07 %. The response of carrots and best root to various fertilizer treatments including N, P, K, lime, FYM and borax were studied by Salonen (1961). Carrots showed less or no response to the treatments. It was however, found that yields of both crops were increased by borax applications. Kelly *et al.* (1952) studied the effects of boron on the growth and carotene content of carrots. Red cored Chantenay carrots were grown in sand culture both in a green-house and in the open field with Hoaglands solution containing boron at the rate of 0.0, 0.1, 0.5, 2.0 and 5.0 ppm. Boron deficiency symptoms developed with no boron and toxicity symptoms with 5.0 ppm. It was reported that in mature carrots, 0.5 ppm boron produced the highest yield of tops while the highest yield of root was obtained with 2.0 ppm boron solution.

CHAPTER III

MATERIALS AND METHODS

This chapter presents a brief description about experimental period, site description, climatic condition, crop or planting materials, treatments, experimental design and layout, crop growing procedure, intercultural operations, data collection and statistical analysis. The details of experiments and methods are described below:

3.1 Experimental period

The experiment was conducted during the period from8 November, 2013 to 20 February, 2014 in Rabi season.

3.2 Site description

3.2.1 Geographical location

The present research work was conducted in the Horticulture Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The location of the site is $23^0 74^/$N latitude and $90^0 35^/$E longitude with an elevation of 8.2 m from sea levels.

3.2.2 Agro-Ecological Region

The experimental site belongs to the agro-ecological zone of “Modhupur Tract”, AEZ-28 (Anon., 1988a). This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as ‘islands’ surrounded by floodplain (Anon., 1988b). The experimental site was shown in the map of AEZ of Bangladesh in Appendix I.

3.2.3 Soil

Top soil was silty clay in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH was 5.6 and has organic carbon 0.45%. The experimental area was flat having available irrigation and drainage system and above flood levels. The selected plot was medium high land. The details were presented in Appendix II.

3.2.4 Climate of the experimental site

Experimental site was located in the sub-tropical monsoon climatic zone, set aparted by winter during the months from 10th November, 2013 to 10th March, 2014 (Rabi season). Plenty of sunshine and moderately low temperature prevails during experimental period, which is suitable for carrot growing in Bangladesh. The weather data during the study period at the experimental site are shown in Appendix III.

3.3 Treatments of the experiment

The experiment was designed to study the effect of cowdung, zinc and boron management on growth and yield of carrot. The experiment consisted of single factor which are as follows:

Factor:

Cowdung = 0 ton ha^{-1}, 10 ton ha^{-1}, 15 ton ha^{-1}, 20 ton ha^{-1}

Zinc = 0 kg ha^{-1}, 2 kg ha^{-1}, 4 kg ha^{-1}, 6 kg ha^{-1}

Boron = 0 kg ha^{-1}, 1 kg ha^{-1}, 2 kg ha^{-1}, 3 kg ha^{-1}

There were altogether 11 treatment combinations such as:

$T_1 = CD_{15} + Zn_0 + B_2$

$T_2 = CD_{15} + Zn_2 + B_2$

$T_3 = CD_{15} + Zn_4 + B_2$

$T_4 = CD_{15} + Zn_6 + B_2$

$T_5 = CD_{15} + Zn_4 + B_0$

$T_6 = CD_{15} + Zn_4 + B_1$

$T_7 = CD_{15} + Zn_4 + B_3$

$T_8 = CD_0 + Zn_4 + B_2$

$T_9 = CD_{10} + Zn_4 + B_2$

$T_{10} = CD_{20} + Zn_4 + B_2$

$T_{11} = CD_0 + Zn_0 + B_0$

3.4 Experimental materials

'New Caroda' variety of carrot was used for the experiment as experiment materials. The seeds of this variety were collected from Dhaka Seed Store, Siddique Bazar, Dhaka.

3.5 Experimental design and layout

The Single factor experiment was laid out following Randomized Complete Block Design (RCBD) with three replications. The four levels of Zn four levels of B and four levels of cowdung formed 11 comprising treatments according to the rules of fertilizer treatment combination of soil sciences division, North carolina university, USA. Each block was divided in to 11 plots where 11 treatments were allotted at

random. Thus, there were 33 (11 × 3) unit plots altogether in the experiment. The size of each plot was 1m × 1m. The distance between blocks and between plots were kept respectively 0.5 cm and 0.5 cm.

3.6 Land preparation

The land which was selected to conduct the experiment was opened on 8 November 2013 with the help of a power tiller and then it was kept open to sun for 7 days prior to further ploughing. Afterwards it was prepared by ploughing and cross ploughing following by laddering. Deep ploughing was done to have a good tilth, which was necessary for getting better yield of this crop. The weeds and stubbles were removed after each laddering. Simultaneously the clods were broken and the soil was made into good tilth.

3.7 Collection and sowing of seeds

The seeds of carrot ‘New Caroda’ was used in the experiment. The seeds were in a sealed container and procured by the Dhaka Seed Store. The seeds were soaked in water for 24 hours and then wrapped with piece of thin cloth. The soaked seeds were then spreaded over polythene sheet for 2 hours to day out the surface water. This treatment was given to help quick germination of seeds. The treated seeds were sown in the field on 15 November, 2013. Small holes about 1.5 cm depth were made at a distance at 15 cm. Along the row spaced at a distance of 25 cm. Three or four seeds were placed in each hole and covered with loose soil.

3.8 Manure and Fertilizerapplication

The doses of zinc, boron and cowdung were appliedas per the treatments. So, entire amount of cowdung was applied at the time of initial land preparation and the whole amount of boric acid and zinc sulpahte were applied during the final land preparation.

3.9 Intercultural operation

3.9.1 Thinning out

Seedlings emergence was completed within 10 days.First thinning was done after 20 days of sowing, leaving two seedlings in each till. The second thinning was done ten days after first thinning, keeping only one seedling in each till.

3.9.2 Weeding

Weeding was done four or five times in plots to keep plots free from weeds.

3.9.3 Pest management

Soil of each plot was treated by Sevin 85WP @ 0.2% at 15 days interval for two times to protect the young plants from the attack of field cricket, mole cricket, cutworm and ants.

3.9.4 Diseases management

The crop was healthy and fungicide was used as and when necessary.

3.10 Harvesting

The crop was harvested on 20 February, 2014 i.e. 95 days after sowing (DAS). Harvesting of the crop was done plot wise. It was done by uprooting the plants by hand carefully. The soil and fibrous roots adhering to the conical roots were removed and cleaned.

3.11 Data collection

Data were recorded from the sample plants on the following parameters during the course of experiment. Ten plants were sampled randomly from each unit plot. The whole plot was harvested to record per plot data. The following parameters were recorded:

3.11.1 Plant height

Plant height was recorded in centimeter (cm) by a meter scale at 45, 55, 65, 75, 85 and 95 DAS from the plot of attachment of the leaves to the root (ground level) up to the tip of the longest leaf.

3.11.2 Number of leaves perplant

Number of leaves per plant was recorded form ten randomly by selected plants at 45, 55, 65, 75, 85 and 95 DAS. All the leaves of each plant were counted separately. Only the smallest young leaves at the growing point of the plant were excluded from the counting and the average number was recorded.

3.11.3 Foliage length

The foliage length of carrot was measured in centimeter with the help of a meter scale from the total foliage point of root in each treatment.

3.11.4 Root length

The length of the conical roots was measured in centimeter with the help of a meter scale from the proximal end of the conical roots to the last point of the tapered end of the root (distal end) in each treatment.

3.11.5 Root diameter

Using a slide calipers. The diameter of the roots were measured in centimeter after harvest at the thickened portion of the root.

3.11.6 Fresh weight of leaves

Leaves were detached by a sharp knife and fresh weight of the leaves was taken by a triple beam balance at harvest (95 DAS) and was recorded.

3.11.7 Percent dry matter of leaves

100 g leaves were collected from the random samples and cut into small pieces and then sun dried for two days. Sun dried samples are then put in paper packets and oven dried for 72 hours at 70 to 80°C in an oven. After oven drying, leaves were weighted. An electric balance was used to record the dry weight of leaf and it was calculated on percentage basis. The percentage of dry matter of leaves was calculated by the following formula.

$$\% \, Drymatterofleaves = \frac{Constantdryweightofleaves}{Freshweightoflevaes} \times 100$$

3.11.8 Fresh weight of root

Carrot roots of single selected plants were made detaching by a knife from the attachment of the stem and after cleaning the soiland fibrous root fresh weight was taken by the triple beam balance in gram and then the average value was calculated.

3.11.9 Percent dry matter of root

100 g root were collected from the random samples and cut into small pieces and then sun dried for two days. Sun dried samples are then put in paper packets and oven dried for 72 hours at 70 to 80°C in an oven. After oven drying, root were weighted. An electric balance was used to record the dry weight of root and it was

calculated on percentage basis. The percentage of dry matter of leaves was calculated by the following formula.

$$\% \, Drymatterofroot = \frac{Constantdryweightofroot}{Freshweightofroot} \times 100$$

3.11.10 Percentage of cracked roots

At harvest, among the carrot roots the number of cracked roots was counted. Then percentage of cracked roots was calculated according to the following formula.

$$Craekedroot(\%) = \frac{Numberofcreakedroot}{Numberoftotalroots} \times 100$$

3.11.11 Percentage of branched roots

At harvest, among the carrot roots the number of branched roots was counted. Then percentage of branched roots was calculated according to the following formula.

$$Branchedroot(\%) = \frac{Numberofbranchedroot}{Numberoftotalroots} \times 100$$

3.11.12 Yield per plot

A balance was used to record the weight of the harvested carrot. All leaves were removed from the plant by a sharp knife and weight of the roots was taken in kilogram (kg) from each unit plot.

3.11.13 Yield per hectare

The yield of roots per hectare was calculated in tone by converting the total yield of roots per plot.

3.12 Statistical analysis

The data obtained for different characters were statistically analyzed to observe the significant difference among the treatment by using the MSTAT-C computer package program. The mean values of all the characters were calculated and analysis of variance was performed. The significance of the difference among the treatments means was estimated by the Least Significant Difference (LSD) at 5% level of probability (Gomez and Gomez, 1984).

3.13 Economic analysis

The cost of production was analyzed in order to find out the most economic treatment of nutrient sources. All input cost were considered in computing the cost of production. The market price of spike, bulb and bulblet was considered for estimating the return. The benefit cost ratio (BCR) was calculated as follows:

$$\text{Benefit cost ratio} = \frac{\text{Gross return per hectare (Tk.)}}{\text{Total cost of production per hectare (Tk.)}}$$

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to find out the effect of cowdung, zinc and boron on growth and yield of carrot (*Daucus carota*). The results obtained from the study have been presented, discussed and compared in this chapter through tables, figures and appendices. The analyses of variance of data in respect of all the parameters have been shown in Appendix IV-X. The results have been presented and discussed with the help of table and graphs and possible interpretations given under the following headings.

4.1 Plant height

The plant height of carrot was measured at 45, 55, 65, 75, 85 and 95 DAS. It was found from Figure 2 and Appendix IV that the height of plant was significantly influenced by fertilizer management at different days after sowing. Figure 2 showed, the carrot plant height increased rapidly at the early stages of growth and rate of progression in height was slow at the later stages except control treatment. At 95 DAS, T_6 (CD_{15} t + Zn_4 kg + B_1 kg/ha) treatment showed the longest plant (61.51 cm), which followed by T_3 (CD_{15} t + Zn_4 kg + B_2 kg/ha) treatment (59.00 cm) whereas, the shortest plant (49.73 cm) was found from T_{11} (CD_0 t + Zn_0 kg + B_0 kg/ha) treatment. Plant height of a crop depends on the plant vigor, cultural practices, growing environment and agronomic management. In the present experiment since carrot was grown in the same environment and were given same cultural practices except fertilizer management. So, the variation of plant height might be due to the effect of different level of fertilizer management. It may be inferred that combined application of cowdung with combination of Zn and B micronutrients may give a better absorption of nutrients and it might have played a dominant role in growth of plant. This finding is in agreement with the result of Thompson and Kelly (1998) reported that manure of value as a source of humus, a source of both major and minor nutrients as a carrier and promoter of beneficial organising and possibly as source of growth promoting substances.

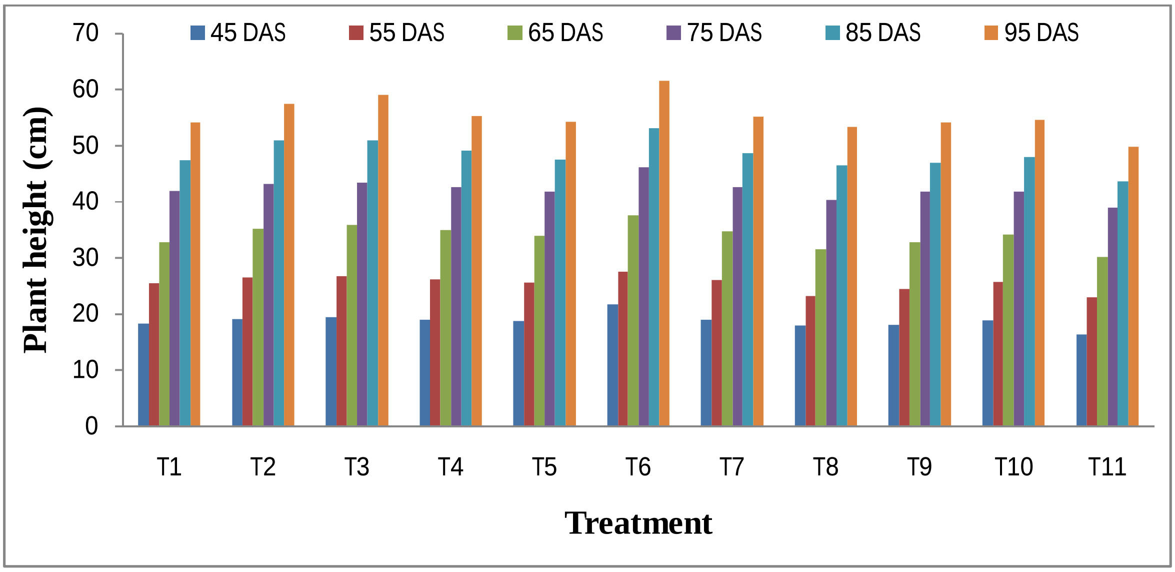

Figure 2. Effect of cowdung, zinc and boron management on plant height of carrot (LSD value = 0.26, 0.31, 0.30, 0.48, 0.43 and 0.43 at 45, 55, 65, 75, 85 and 95 DAS, respectively)

$T_1 = CD_{15}$ t + Zn_0 kg + B_2 kg/ha,
$T_2 = CD_{15}$ t + Zn_2 kg + B_2 kg/ha,
$T_3 = CD_{15}$ t + Zn_4 kg + B_2 kg/ha,
$T_4 = CD_{15}$ t + Zn_6 kg + B_2 kg/ha,
$T_5 = CD_{15}$ t + Zn_4 kg + B_0 kg/ha,
$T_6 = CD_{15}$ t + Zn_4 kg + B_1 kg/ha,
$T_7 = CD_{15}$ t + Zn_4 kg + B_3 kg/ha,
$T_8 = CD_0$ t + Zn_4 kg + B_2 kg/ha,
$T_9 = CD_{10}$ t +Zn_4 kg + B_2 kg/ha,
$T_{10} = CD_{20}$ t + Zn_4 kg + B_2 kg/ha and
$T_{11} = CD_0$ t + Zn_0 kg + B_0 kg/ha.

4.2 Number of leaves per plant

The number of leaves per plant was significantly influenced by different fertilizer management at 45, 55, 65, 75, 85 and 95 days after sowing (DAS) (Appendix IV and Figure 3). The number of leaves per plant gradually increased with the advancement of plant age up to harvest and thereafter more or less remain static with advancing growing period, irrespective of different fertilizer management. At

95 DAS, T_6 (CD_{15} t + Zn_4 kg + B_1 kg/ha) treatment showed the maximum number (14.27) of leaves per plant which followed by T_3 (12.40) treatment whereas, the minimum number (10.00) was found from T_{11} (CD_0 t + Zn_0 kg + B_0 kg/ha) treatment. From the results of present study it can be said that application of cowdung with combination of Zn and B provided better growing conditions perhaps due to supply of adequate plant nutrients resulting maximum number of leaves. Patwary *et al.* (2015) reported that fertilizer doses had significant influence on number of leaves.

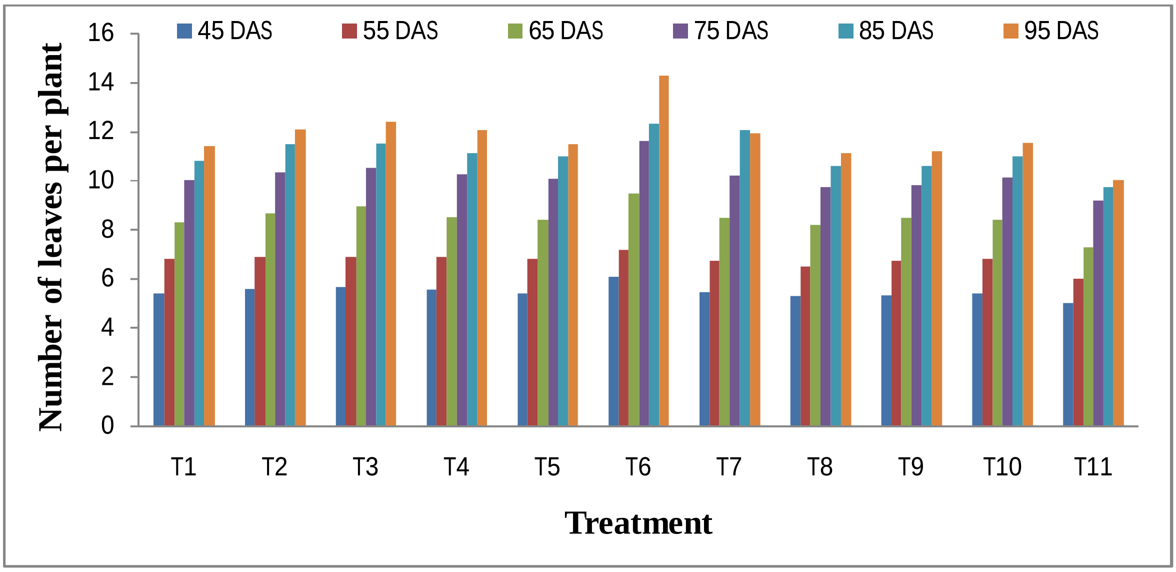

Figure 3. Effect of cowdung, zinc and boron management on number of leaves per plant of carrot (LSD value = 0.32, 0.27, 0.33, 0.33, 0.55 and 0.12 at 45, 55, 65, 75, 85 and 95 DAS, respectively)

T_1 = CD_{15} t + Zn_0 kg + B_2 kg/ha,
T_2 = CD_{15} t + Zn_2 kg + B_2 kg/ha,
T_3 = CD_{15} t + Zn_4 kg + B_2 kg/ha,
T_4 = CD_{15} t + Zn_6 kg + B_2 kg/ha,
T_5 = CD_{15} t + Zn_4 kg + B_0 kg/ha,
T_6 = CD_{15} t + Zn_4 kg + B_1 kg/ha,
T_7 = CD_{15} t + Zn_4 kg + B_3 kg/ha,
T_8 = CD_0 t + Zn_4 kg + B_2 kg/ha,
T_9 = CD_{10} t +Zn_4 kg + B_2 kg/ha,
T_{10} = CD_{20} t + Zn_4 kg + B_2 kg/ha and
T_{11} = CD_0 t + Zn_0 kg + B_0 kg/ha.

4.3 Foliage length

Statistically significant differences were found for foliage length per plant of carrot due to fertilizer management (Appendix VI and Table 1). The highest foliage length per plant (75.47 cm) was recorded from T_6 (CD_{15} t + Zn_4 kg + B_1 kg/ha) treatment which following by T_3 (CD_{15} t + Zn_4 kg + B_2 kg/ha) (70.33 cm), T_2 (CD_{15} t + Zn_2 kg + B_2 kg/ha) (69.80 cm), T_4 (CD_{15} t + Zn_6 kg + B_2 kg/ha) (69.67 cm) and T_7 (CD_{15} t + Zn_4 kg + B_3 kg/ha) (69.27 cm) treatments respective by the lowest foliage length per plant (60.07 cm) was observed from T_{11} (CD_0 t + Zn_0 kg + B_0 kg/ha) treatment. This results indicated that cowdung manure with micronutrients combinatory supplied balanced plants nutrients and provided better growing condition, which helped for getting proper negative growth as well as maximum foliage length. Soil organic matter is the key of soil fertility since it regulates the soil water and air supply. Plants required boron for a number of growth process such as new development in meristeimatic tissue, translocation of sugars, starches, nitrogen, phosphorus and synthesis of amino acids and protein (Tisdala *et al.*, 1984).

4.4 Fresh weight of leaves

Fresh leaves weight per plant of carrot differed significantly due to fertilizer management (Appendix VI and Table 1). The maximum fresh leaves weight per plant (232.10 g) was observed from T_6 (CD_{15} t + Zn_4 kg + B_1 kg/ha) treatment which followed by T_3 (CD_{15} t + Zn_4 kg + B_2 kg/ha) (227.10 g) treatment. The minimum fresh leaves weight per plant (181.00 g) was observed from T_{11} (CD_0 t + Zn_0 kg + B_0 kg/ha) treatment. Fresh leaf weight per plant is an important yield contributing factor in this vegetable crop. Optimum levels of cowdung with Zn and B fertilizers might have regulate some important physiological process, which occurs influenced better vegetative performance of the crop and ultimately produced more fresh leaves weight. Similar findings was observed by Theunissen *et al.*(2010).

They reported that plant nutrients including N, P, K, Zn and B the uptake of which has a positive effect on plant nutrient, photosynthesis, the chlorophyll content of the leaves and improving the nutrient content of the different plant compounds of carrots (leaf, shoots and roots).

Table 1. Effect of cowdung, zinc and boron management on foliage length, fresh weight of leaves, root length and root diameter of carrot

Treatments	Foliage length (cm)	Fresh weight of leaves (g)	Root length (cm)	Root diameter (cm)
T_1	66.80 g	220.30 f	15.27 e	4.43 b
T_2	69.80 c	223.50 c	17.27 bc	4.63 b
T_3	70.33 b	227.10 b	17.93 b	4.63 b
T_4	69.67 c	223.10 c	17.13 bc	4.53 b
T_5	67.93 f	220.80 ef	16.53 cd	4.47 b
T_6	75.47 a	232.10 a	21.00 a	5.17 a
T_7	69.27 d	222.00 d	16.73 cd	4.50 b
T_8	66.49 g	196.30 h	15.87 de	4.33 b
T_9	66.60 g	216.10 g	16.07 de	4.37 b
T_{10}	68.80 e	221.30 e	16.73 cd	4.47 b
T_{11}	60.07 h	181.00 i	13.47 f	3.60 c
$LSD_{(0.05)}$	0.39	0.56	1.03	0.33
CV (%)	2.33	1.15	3.62	4.31

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability

$T_1 = CD_{15}$ t + Zn_0 kg + B_2 kg/ha,
$T_2 = CD_{15}$ t + Zn_2 kg + B_2 kg/ha,
$T_3 = CD_{15}$ t + Zn_4 kg + B_2 kg/ha,
$T_4 = CD_{15}$ t + Zn_6 kg + B_2 kg/ha,
$T_5 = CD_{15}$ t + Zn_4 kg + B_0 kg/ha,
$T_6 = CD_{15}$ t + Zn_4 kg + B_1 kg/ha,
$T_7 = CD_{15}$ t + Zn_4 kg + B_3 kg/ha,
$T_8 = CD_0$ t + Zn_4 kg + B_2 kg/ha,
$T_9 = CD_{10}$ t +Zn_4 kg + B_2 kg/ha,
$T_{10} = CD_{20}$ t + Zn_4 kg + B_2 kg/ha and
$T_{11} = CD_0$ t + Zn_0 kg + B_0 kg/ha.

4.5 Root length

A remarkable difference in respect of root length of carrot plant was found significant due to the effect of different fertilizer treatments (Appendix VI and Table 1). The maximum root length (21.00 cm) was obtained from T_6 (CD_{15} t + Zn_4 kg + B_1 kg/ha) treatment, whereas the minimum root length (13.47 cm) was found from that of T_{11} (CD_0 t + Zn_0 kg + B_0 kg/ha) treatment. It was probably due to the fact that organic manure with combination of optimum doses of micronutrients may be responsible for creating favorable soil conditions and supplying the required nutrients for better growth and development, which help to the production of maximum root length. Schuch *et al.* (1999) reported that root length varied different amount of manure applied and application of organic manure generally increased the parameters evaluated. Rasp (1985) reported that only boron treatment increased carrot yield. Quaggio and Ramos (1986) also reported that boron was more pronounced on the yield and large sized roots than on small once.

4.6 Root diameter

Root diameter per plant was found significant due to different fertilizers treatments (Appendix VI and Table 1). The maximum root diameter (5.17 cm) was produced by T_6 (CD_{15} t + Zn_4 kg + B_1 kg/ha) treatment. On the other hand, control produced minimum (3.60 cm) diameter of root was produced by T_{11} (CD_0 t + Zn_0 kg + B_0 kg/ha) treatment. The rest of treatments showed statistically similar results in this respect. This experiment resulted that application of cowdung with the combination of Zn and B produced the highest root diameter of carrot. The increase in individual root diameter might be due to optimum levels of cowdung with combination of Zn and B improved physiological condition of the soil, water holding capacity and make available more nutrients for uptake by the crop. Patwary *et al.* (2015) reported that fertilizer doses had significant influence on all of the characters along with root diameter of carrot. Schuch *et al.* (1999) reported that root diameter varied different amount of manure applied and application of organic manure generally increased the parameters evaluated.

4.7 Percentage of dry matter of leaves

The different fertilizers management practices significantly influenced the production of dry matter of leaves (Appendix VII and Table 2). The highest percentage dry matter content of leaves (20.10) was obtained from T_6 (CD_{15} t + Zn_4 kg + B_1 kg/ha) treatment. The minimum percentage dry matter content of leaves (15.30) was obtained from T_{11} (CD_0 t + Zn_0 kg + B_0 kg/ha) treatment. The dry weight produced by the plants may be attributed to the provision of favorable soil condition to the supply of required nutrient for better growth and development, leaves to produce higher amount of dry matter in leaves. Alekseeva and Rasskazorv (1976) found that boron application increased the total yield by 6.2-13.2 % and commercial yield by up to 6.3 % of carrot. Increase in sugar, carotene, dry matter contents were also observed.

4.8 Fresh weight of root per plant

Significant variation in respect of fresh weight of individual root was observed due to different fertilizers management practices (Appendix VII and Table 2). The maximum fresh weight (160.70 g) of individual root was obtained by T_6 (CD_{15} t + Zn_4 kg + B_1 kg/ha) treatment and the minimum weight of root (117.50 g) was recorded from T_{11} (CD_0 t + Zn_0 kg + B_0 kg/ha) treatment. From the above results, it was noted that cowdung with combination of (Zn and B) micronutrients possibly maintain higher moisture contain in soil and increase the release of more plant nutrients from organic source and micronutrients, which ultimately reflect much root formation. The available soil nutrient support proper vegetative growth. Kale *et al*. Bano (1991) reported that micronutrients increases the root weight and root shoot ratio. Patwary (2015) also found the similar result incase of root fresh weight of carrot. He reported that highest fresh root weight (110.00 g) was obtained with combined application of cowdung, macro and micro nutrients. Kabir *et al.* (1994) reported that application of Boron showed positive response to yield of carrot. Maurya and Singh (1985) also observed that Zn (10 kg/ha) gave the highest yield of carrot over the control and the best quality indices.

Table 2. Effect of cowdung, zinc and boron on dry matter of leaves (%), fresh weight of root per plant and dry matter of root (%) of carrot

Treatments	Dry matter of leaves (%)	Fresh weight of root plant^{-1} (g)	Dry matter of root (%)
T_1	17.40 f	141.50 ef	10.03 h
T_2	18.95 b	153.50 b	11.25 c
T_3	19.00 b	153.60 b	11.35 b
T_4	18.76 bc	147.20 cd	11.18 d
T_5	17.86 e	143.70 de	10.34 g
T_6	20.10 a	160.70 a	12.35 a
T_7	18.67 c	151.80 bc	11.00 e
T_8	16.87 g	137.70 f	9.12 j
T_9	17.20 f	138.60 ef	9.67 i
T_{10}	18.35 d	150.10 bc	10.78 f
T_{11}	15.30 h	117.50 g	8.45 k
$LSD_{(0.05)}$	0.28	5.48	0.05
CV (%)	2.67	3.24	2.56

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability

$T_1 = CD_{15}$ t + Zn_0 kg + B_2 kg/ha,
$T_2 = CD_{15}$ t + Zn_2 kg + B_2 kg/ha,
$T_3 = CD_{15}$ t + Zn_4 kg + B_2 kg/ha,
$T_4 = CD_{15}$ t + Zn_6 kg + B_2 kg/ha,
$T_5 = CD_{15}$ t + Zn_4 kg + B_0 kg/ha,
$T_6 = CD_{15}$ t + Zn_4 kg + B_1 kg/ha,
$T_7 = CD_{15}$ t + Zn_4 kg + B_3 kg/ha,
$T_8 = CD_0$ t + Zn_4 kg + B_2 kg/ha,
$T_9 = CD_{10}$ t +Zn_4 kg + B_2 kg/ha,
$T_{10} = CD_{20}$ t + Zn_4 kg + B_2 kg/ha and
$T_{11} = CD_0$ t + Zn_0 kg + B_0 kg/ha.

4.9 Percentage of dry matter of root

Percent dry mater of root was found to be significantly influenced by fertilizer management practices (Apendix VII and Table 2). The highest dry matter of root (12.35 %) was obtained from the plants grown under T_6 (CD_{15} t + Zn_4 kg + B_1 kg/ha) treatment. On the other hand, the minimum (8.45 %) was recorded from the plants grown under T_{11} (CD_0 t + Zn_0 kg + B_0 kg/ha) treatment. This might be due to the balanced application of fertilizer which increased plant height, number of leaves and chlorophyll production of the plant. Patwary (2015) also observed similar result in this respect. He reported that percent dry matter content of root of carrot was highest (11.20 %) when plant grown under combined application of cowdung with Urea-TSP-MOP-Boron-Zinc @ 195-132-120-89-10-20 kg /ha. Hochmuth and Howell (1983) reported that leaf area, leaf number, total dry weight and highest marketable yield was obtained from cowdung application.

4.10 Percentage of cracked roots

The percent cracked root production was also significant in respect of the same parameter by the different fertilizers management practices (Appendix VIII and Table 3). The highest cracked root percent (13.32) was found from T_{11} (CD_0 t + Zn_0 kg + B_0 kg/ha) treatment. No cracked roots were found in the treatment $T_{2,}T_3$ and T_6. This may be due to the vigorous growth of carrot encouraged by the balanced fertilizer application. The present study referred that control treatment (CD_0 t + Zn_0 kg + B_0 kg/ha) produced maximum percent of cracked root. Purvis and Carolus (1964) mentioned that in case of boron deficiency in root vegetables, the root surfaces often were wrinkled and cracked.

Table 3. Effect of cowdung, zinc and boron management on cracked roots (%) and branched roots (%) of carrot

Treatments	Cracked roots (%)	Branched roots (%)
T_1	6.67 b	22.33 c
T_2	0.00 d	14.67 g
T_3	0.00 d	12.33 h
T_4	3.32 c	16.00 f
T_5	6.67 b	20.67 d
T_6	0.00 d	8.00 i
T_7	3.32 c	18.33 e
T_8	6.67 b	24.33 b
T_9	6.67 b	22.33 c
T_{10}	6.67 b	20.67 d
T_{11}	13.32 a	26.67 a
$LSD_{(0.05)}$	0.39	1.60
CV (%)	4.66	2.63

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability

T_1 = CD_{15} t + Zn_0 kg + B_2 kg/ha,
T_2 = CD_{15} t + Zn_2 kg + B_2 kg/ha,
T_3 = CD_{15} t + Zn_4 kg + B_2 kg/ha,
T_4 = CD_{15} t + Zn_6 kg + B_2 kg/ha,
T_5 = CD_{15} t + Zn_4 kg + B_0 kg/ha,
T_6 = CD_{15} t + Zn_4 kg + B_1 kg/ha,
T_7 = CD_{15} t + Zn_4 kg + B_3 kg/ha,
T_8 = CD_0 t + Zn_4 kg + B_2 kg/ha,
T_9 = CD_{10} t +Zn_4 kg + B_2 kg/ha,
T_{10} = CD_{20} t + Zn_4 kg + B_2 kg/ha and
T_{11} = CD_0 t + Zn_0 kg + B_0 kg/ha.

4.11 Percentage of branched roots

The percent branched roots differed significantly with different fertilizer management practices (Appendix VIII and Table 3). The maximum branched root (26.67 %) was observed from T_{11} (CD_0 t + Zn_0 kg + B_0 kg/ha) treatment. On the other hand, minimum (8.00 %) was recorded from T_6 (CD_{15} t + Zn_4 kg + B_1 kg/ha) treatment. The present study referred that application of the control treatment (CD_0 t + Zn_0 kg + B_0 kg/ha) produced the highest percent of branched root.

4.12 Yield per plot and per hectare

Statistically significant differences in yield per plot of carrot were recorded for the effect of different fertilizer management practices (Appendix IX and Table 4). The highest yield per plot (6.17 kg) was recorded from T_6 (CD_{15} t + Zn_4 kg + B_1 kg/ha) treatment. The lowest yield per plot (2.84 kg) was found in T_{11} (CD_0 t + Zn_0 kg + B_0 kg/ha) treatment.

Fertilizer management differed significantly in producing yield of carrot per hectare (Appendix IX and Table 4). The maximum yield per hectare (59.67 t) was observed from T_6 (CD_{15} t + Zn_4 kg + B_1 kg/ha) treatment whereas, the minimum (28.45 t/ha) was obtained from T_{11} (CD_0 t + Zn_0 kg + B_0 kg/ha) treatment. This experiment resulted that application of Cowdung-Zinc sulphate-Boric acid @ 15t - 4kg - 1kg/ha produced maximum yield of carrot. Kabir *et al.* (1994) reported that application of boron with different levels showed positive response to yield of carrot. Efkar *et al.* (1995) reported that generally all the fertilizer treatments increased yield over control. Akand (2003) reported that cowdung @ 15 t/ha significantly resulted the highest yield of carrot of this experiment. Oliveira *et al.* (2001) reported that Cowdung @ 25 t ha^{-1} produced the highest total (70.1 t/ha). Lang (1984) found that organic manures increased the yield of carrot (10-12 %) compared with control.

Table 4. Effect of cowdung, zinc and boron management on yield per plot and yield per ha of carrot

Treatments	Yield per plot (kg)	Yield (t/ha)
T_1	4.63 e	46.33 e
T_2	5.20 bc	52.00 c
T_3	5.37 b	55.67 b
T_4	5.03 cd	50.33 cd
T_5	4.70 e	47.00 e
T_6	6.17 a	59.67 a
T_7	4.97 d	49.67 d
T_8	4.17 g	39.67 g
T_9	4.40 f	44.00 f
T_{10}	4.73 e	47.33 e
T_{11}	2.84 h	28.45 h
$LSD_{(0.05)}$	0.23	2.22
CV (%)	2.80	2.71

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 level of probability

$T_1 = CD_{15}$ t + Zn_0 kg + B_2 kg/ha,
$T_2 = CD_{15}$ t + Zn_2 kg + B_2 kg/ha,
$T_3 = CD_{15}$ t + Zn_4 kg + B_2 kg/ha,
$T_4 = CD_{15}$ t + Zn_6 kg + B_2 kg/ha,
$T_5 = CD_{15}$ t + Zn_4 kg + B_0 kg/ha,
$T_6 = CD_{15}$ t + Zn_4 kg + B_1 kg/ha,
$T_7 = CD_{15}$ t + Zn_4 kg + B_3 kg/ha,
$T_8 = CD_0$ t + Zn_4 kg + B_2 kg/ha,
$T_9 = CD_{10}$ t +Zn_4 kg + B_2 kg/ha,
$T_{10} = CD_{20}$ t + Zn_4 kg + B_2 kg/ha and
$T_{11} = CD_0$ t + Zn_0 kg + B_0 kg/ha.

4.13 Economic analysis

Input costs for land preparation, fertilizer, irrigation and manpower required for all the operations from seed sowing to harvesting of carrot were recorded as per experimental plot and converted into cost per hectare (Appendix X). Price of carrot was considered as per market rate. The economic analysis presented under the following headings-

4.13.1 Gross return

The combination of different levels of cowdung, zinc and boron showed different value in terms of gross return under the trial (Table 5). The highest gross return (Tk. 4,77,360.00) was obtained from T_6 (CD_{15} t + Zn_4 kg + B_1 kg/ha) treatment and the second highest gross return (Tk. 4,45,360.00) was found in T_3 (CD_{15} t + Zn_4 kg + B_2 kg/ha) treatment. The lowest gross return (Tk. 2,27,600.00) was obtained from T_{11} (CD_0 t + Zn_0 kg + B_0 kg/ha) treatment.

4.13.2 Net return

In case of net return, different levels of cowdung, zinc and boron showed different levels of net return under the present trial (Table 5). The highest net return (Tk. 3,34,226.24) was found from T_6 (CD_{15} t + Zn_4 kg + B_1 kg/ha) treatment and the second highest net return (Tk. 3,02,206.08) was obtained from T_3 (CD_{15} t + Zn_4 kg + B_2 kg/ha). The lowest (Tk. 1,18,176.00) net return was obtained T_{11} (CD_0 t + Zn_0 kg + B_0 kg/ha) treatment.

4.13.3 Benefit cost ratio

In the different levels of cowdung, zinc and boron, the highest benefit cost ratio (3.34) was noted from T_6 (CD_{15} t + Zn_4 kg + B_1 kg/ha) treatment and the second highest benefit cost ratio (3.11) was estimated from T_3 (CD_{15} t + Zn_4 kg + B_2 kg/ha). The lowest benefit cost ratio (2.08) was obtained from T_{11} (CD_0 t + Zn_0 kg + B_0 kg/ha) treatment (Table 5). From economic point of view, it is apparent from the above results that T_6 (CD_{15} t + Zn_4 kg + B_1 kg/ha) treatment was better than rest of the combination.

Table 5. Cost and return of carrot cultivation as influenced by different levels of cowdung, zinc and boron

Treatments	Cost of production (Tk./ha)	Yield of cabbage (t/ha)	Gross return (Tk./ha)	Net return (Tk./ha)	Benefit cost ratio
T_1	1,43,064.32	46.33	3,70,640.00	2,27,575.68	2.59
T_2	1,43,109.12	52.00	4,16,000.00	2,72,890.88	2.91
T_3	1,43,153.92	55.67	4,45,360.00	3,02,206.08	3.11
T_4	1,43,198.72	50.33	4,02,640.00	2,59,441.28	2.81
T_5	1,43,113.60	47.00	3,76,000.00	2,32,886.40	2.63
T_6	1,43,133.76	59.67	4,77,360.00	3,34,226.24	3.34
T_7	1,43,174.08	49.67	3,97,360.00	2,54,185.92	2.78
T_8	1,09,553.92	39.67	3,17,360.00	2,07,806.08	2.90
T_9	1,31,953.92	44.00	3,52,000.00	2,20,046.08	2.67
T_{10}	1,54,355.92	47.33	3,78,640.00	2,24,284.08	2.45
T_{11}	1,09,424.00	28.45	2,27,600.00	1,18,176.00	2.08

Price of Carrot @ Tk. 8000/ton, Cowdung @ Tk. 2000/ton, Zinc @ Tk. 20/kg, Boron @ 18/kg

T_1 = CD_{15} t + Zn_0 kg + B_2 kg/ha,
T_2 = CD_{15} t + Zn_2 kg + B_2 kg/ha,
T_3 = CD_{15} t + Zn_4 kg + B_2 kg/ha,
T_4 = CD_{15} t + Zn_6 kg + B_2 kg/ha,
T_5 = CD_{15} t + Zn_4 kg + B_0 kg/ha,
T_6 = CD_{15} t + Zn_4 kg + B_1 kg/ha,
T_7 = CD_{15} t + Zn_4 kg + B_3 kg/ha,
T_8 = CD_0 t + Zn_4 kg + B_2 kg/ha,
T_9 = CD_{10} t +Zn_4 kg + B_2 kg/ha,
T_{10} = CD_{20} t + Zn_4 kg + B_2 kg/ha and
T_{11} = CD_0 t + Zn_0 kg + B_0 kg/ha.

CHAPTER V

SUMMARY AND CONCLUSION

The field experiment was conducted in the Horticultural farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 during the period from 8 November, 2013 to 20 February, 2014 in Rabi season to find out the effect of cowdung, zinc and boron on the growth and yield of carrot. The experiment consisted of single factor viz. T_1 = CD_{15} t + Zn_0 kg + B_2 kg/ha, T_2 = CD_{15} t + Zn_2 kg + B_2 kg/ha, T_3 = CD_{15} t + Zn_4 kg + B_2 kg/ha, T_4 = CD_{15} t + Zn_6 kg + B_2 kg/ha, T_5 = CD_{15} t + Zn_4 kg + B_0 kg/ha, T_6 = CD_{15} t + Zn_4 kg + B_1 kg/ha, T_7 = CD_{15} t + Zn_4 kg + B_3 kg/ha, T_8 = CD_0 t + Zn_4 kg + B_2 kg/ha, T_9 = CD_{10} t +Zn_4 kg + B_2 kg/ha, T_{10} = CD_{20} t + Zn_4 kg + B_2 kg/ha and T_{11} = CD_0 t + Zn_0 kg + B_0 kg/ha. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replication. Data on different growth and yield contributing characters were recorded.

The plant height and number of leaves per plant was significantly influenced by fertilizer management at different days after sowing. At 95 DAS, T_6 (CD_{15} t + Zn_4 kg + B_1 kg/ha) treatment showed the longest plant (61.51 cm) and highest leaves (14.27). The maximum foliage length per plant (75.47 cm), fresh leaves weight per plant (232.10 g), root length (21.00 cm), root diameter (5.17 cm), percentage dry matter content of leaves (20.10), fresh weight (160.70 g), dry matter of root (12.35 %), yield per plot (6.17 kg) and yield per hectare (59.67 t) was recorded from T_6 (CD_{15} t + Zn_4 kg + B_1 kg/ha) treatment. On the other hand, the highest cracked root percent (13.32) and branched root (59.67 %) was found from T_{11} (CD_0 t + Zn_0 kg + B_0 kg/ha) treatment. At 95 DAS, the lowest plant height (49.73 cm), number of leaves per plant (10.00) was found from T_{11} (CD_0 t + Zn_0 kg + B_0 kg/ha) treatment. The lowest foliage length per plant (60.07 cm), fresh leaves weight per plant (181.00 g), root length (13.47 cm), diameter of root (3.60 cm), percentage dry matter content of leaves (15.30), weight of root (117.50 g), percentage dry matter content of root (8.45 %), yield per plot (2.84 kg) and yield (28.45 t/ha) were observed from T_{11} (CD_0 t + Zn_0 kg + B_0 kg/ha) treatment. The lowest cracked root (3.32 %) and broken root (10.00 %) were obtained from T_4 (CD_{15} t + Zn_6 kg + B_2 kg/ha) treatment.

In the different levels of cowdung, zinc and boron the highest benefit cost ratio (3.34) was noted from T_6 (CD_{15} t + Zn_4 kg + B_1 kg/ha) treatment and the lowest benefit cost ratio (2.08) was estimated from T_{11} (CD_0 t + Zn_0 kg + B_0 kg/ha) treatment.

Conclusion :

On the basis of results of the present experiment, it may be concluded that efficient production of carrot is increased by the judicial application of cowdung with Zn and B micronutrients. Excess application causes antagonistic effect bon plant. Application of cowdung with combination of micronutrients is one of the important management practices to improve soil productivity. Crop yield and profit are both important for a crop production. Soil health is also very important for sustainable production. Thus, considering crop productivity, economic return and soil fertility, combined application of cowdung, Zn and B may be helpful for sustainable crop. So, T_6 (CD_{15} t + Zn_4 kg + B_1 kg/ha) may be beneficial at farmers land for profitable carrot production without affecting the soil health.

The present research work was carried out at the Sher-e-Bangla Agriculture University, Dhaka and one season only. Further trail of this research work in different locations with another variety of the country is needed to justify the result for common farmers.

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Appendix IV: Analysis of variance (mean square) of plant height of carrot at different days after sowing

Sources of variation	Degrees of freedom	Mean Square of plant height at different days after sowing					
		45 DAS	55 DAS	65 DAS	75 DAS	85 DAS	95 DAS
Replication	2	39.749	81.380	42.976	66.231	8.857	88.988
Treatment	10	9.666*	18.114*	30.998**	42.728**	98.249**	108.095**
Error	20	5.326	20.921	25.318	14.619	20.410	23.999

* indicates significant at 5% level of probability.
** indicates significant at 1% level of probability.

Appendix V: Analysis of variance (mean square) of number of leaves per plant of carrot at different days after sowing

Sources of variation	Degrees of freedom	Mean Square of tiller numberhill^{-1} at different days after sowing					
		45 DAS	55 DAS	65 DAS	75 DAS	85 DAS	95 DAS
Replication	2	3.358	4.899	4.801	0.830	1.328	26.768
Treatment	10	3.337**	8.261*	6.557**	16.159**	11.867**	8.156**
Error	20	1.045	4.312	2.856	7.521	3.878	2.672

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

Appendix VI: Analysis of variance (mean square) of foliage length, fresh weight of leaves, root length and root diameter of carrot

Sources of variation	Degrees of freedom	Mean Square			
		Foliage length (cm)	Fresh weight of leaves (g)	Root length (cm)	Root diameter (cm)
Replication	2	2.254	1.841	50.094	8.950
Treatment	10	11.405*	4.249**	1191.270**	1223.273**
Error	20	5.555	0.576	207.939	186.625

* indicates significant at 5% level of probability.
** indicates significant at 1% level of probability.

Appendix VII: Analysis of variance (mean square) of dry matter of leaves (%), fresh weight of root per plant and dry matter of root (%) of carrot

Sources of variation	Degrees of freedom	Mean square		
		Dry matter of leaves (%)	Fresh weight of root per plant (g)	Dry matter of root (%)
Replication	2	63.062	0.589	453.867
Treatment	10	87.018**	2.732**	79.122 *
Error	20	24.410	1.078	37.258

* indicates significant at 5% level of probability.
** indicates significant at 1% level of probability.

Appendix VIII: Analysis of variance (mean square) of cracked roots (%) and branched roots (%) of carrot

Sources of variation	Degrees of freedom	Mean square	
		Cracked roots (%)	Branched roots (%)
Replication	2	0.379	43.922
Treatment	10	16.409**	68.178**
Error	20	4.345	20.539

* indicates significant at 5% level of probability.
** indicates significant at 1% level of probability.

Appendix IX: Analysis of variance (mean square) of yield of carrot

Sources of variation	Degrees of freedom	Mean square	
		Yield per plot (kg)	Yield per hectare (ton)
Replication	2	0.352	25.686
Treatment	10	8.038**	39.474*
Error	20	2.645	22.337

* indicates significant at 5% level of probability.
** indicates significant at 1% level of probability.

Appendix X: Cost of production of carrot per hectare

A. Input cost (Tk/ha)

Treatments	Labor	Onion seed	Pesticides	Irrigation	cow dung	Fertilizer					Subtotal(A)
						Urea	TSP	MOP	Zinc	Boron	
T_1	5,21,00	6,500	2,500	1,500	30,000	1,500	3,600	5,000	00	36	1,02,736
T_2	5,21,00	6,500	2,500	1,500	30,000	1,500	3,600	5,000	40	36	1,02,776
T_3	5,21,00	6,500	2,500	1,500	30,000	1,500	3,600	5,000	80	36	1,02,816
T_4	5,21,00	6,500	2,500	1,500	30,000	1,500	3,600	5,000	120	36	1,02,856
T_5	5,21,00	6,500	2,500	1,500	30,000	1,500	3,600	5,000	80	00	1,02,780
T_6	5,21,00	6,500	2,500	1,500	30,000	1,500	3,600	5,000	80	18	1,02,798
T_7	5,21,00	6,500	2,500	1,500	30,000	1,500	3,600	5,000	80	54	1,02,834
T_8	5,21,00	6,500	2,500	1,500	00	1,500	3,600	5,000	80	36	72,816
T_9	5,21,00	6,500	2,500	1,500	20,000	1,500	3,600	5,000	80	36	92,816
T_{10}	5,21,00	6,500	2,500	1,500	40,000	1,500	3,600	5,000	80	36	1,12,816
T_{11}	5,21,00	6,500	2,500	1,500	00	1,500	3,600	5,000	00	00	72,700

$T_1 = CD_{15}$ t + Zn_0 kg + B_2 kg/ha,
$T_2 = CD_{15}$ t + Zn_2 kg + B_2 kg/ha,
$T_3 = CD_{15}$ t + Zn_4 kg + B_2 kg/ha,
$T_4 = CD_{15}$ t + Zn_6 kg + B_2 kg/ha,
$T_5 = CD_{15}$ t + Zn_4 kg + B_0 kg/ha,
$T_6 = CD_{15}$ t + Zn_4 kg + B_1 kg/ha,
$T_7 = CD_{15}$ t + Zn_4 kg + B_3 kg/ha,
$T_8 = CD_0$ t + Zn_4 kg + B_2 kg/ha,
$T_9 = CD_{10}$ t +Zn_4 kg + B_2 kg/ha,
$T_{10} = CD_{20}$ t + Zn_4 kg + B_2 kg/ha and
$T_{11} = CD_0$ t + Zn_0 kg + B_0 kg/ha.

Cowdung: Tk. 2/kg
Urea: Tk. 12/kg
TSP: Tk. 24/kg
MOP: Tk. 25/kg
Zinc: Tk. 20/kg
Boron: Tk. 18/kg

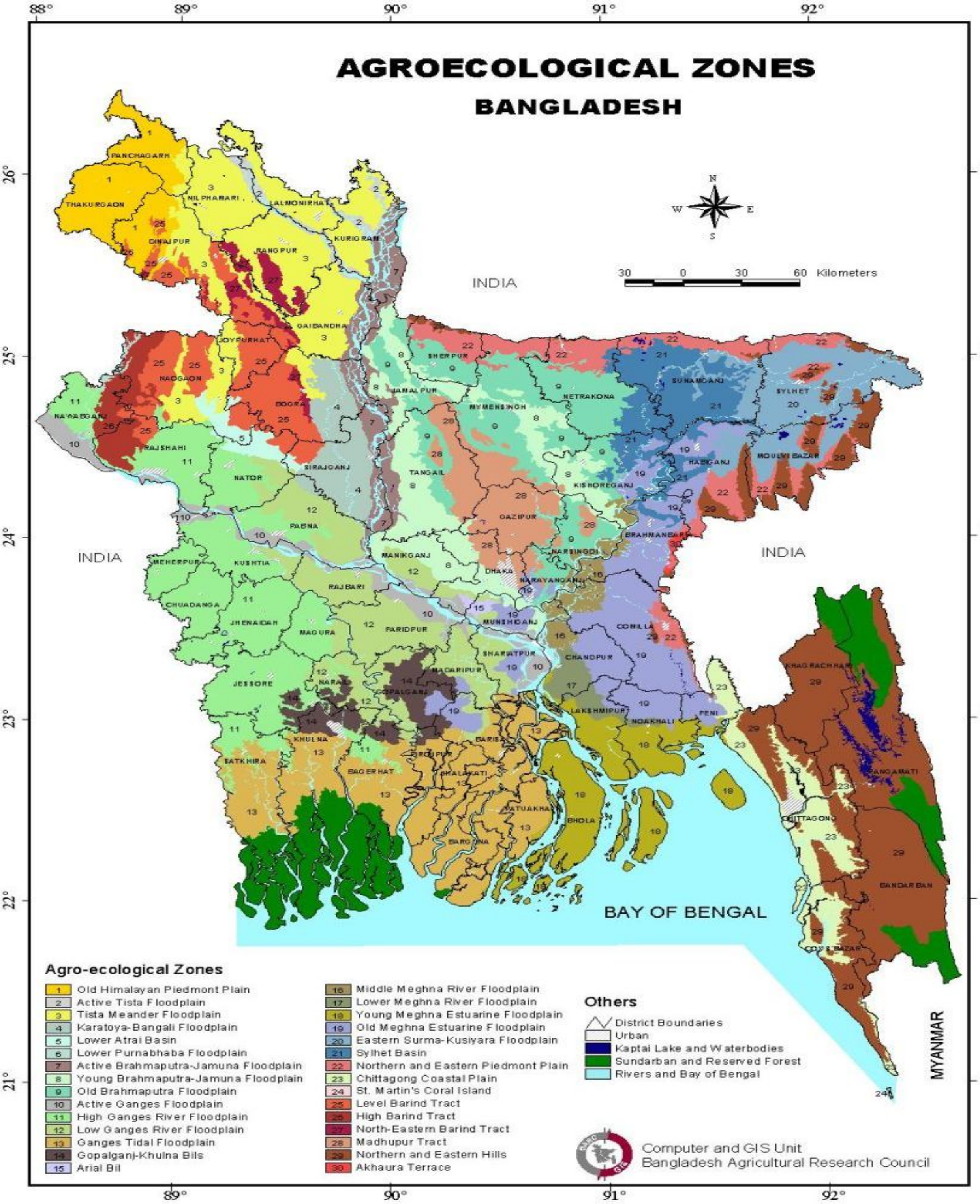
Appendix X: continued

B. Overhead cost (Tk/ha)

Treatments	Cost of lease of land months for 6 months (14% of value of land Tk. 4,00,000/ year)	Miscellaneous cost (Tk. 5% of the input cost)	Interest on running capital for 6 month (14% of cost /year)	Subtotal (B)	Subtotal(A)	Total cost of production (input cost +overhead cost)
T_1	28,000	5,136.80	7,191.52	40,328.32	1,02,736	1,43,064.32
T_2	28,000	5,138.80	7,194.32	40,333.12	1,02,776	1,43,109.12
T_3	28,000	5,140.80	7,197.12	40,337.92	1,02,816	1,43,153.92
T_4	28,000	5,142.80	7,199.92	40,342.72	1,02,856	1,43,198.72
T_5	28,000	5,139.00	7,194.60	40,333.60	1,02,780	1,43,113.60
T_6	28,000	5,139.90	7,195.86	40,335.76	1,02,798	1,43,133.76
T_7	28,000	5,141.70	7,198.38	40,340.08	1,02,834	1,43,174.08
T_8	28,000	3,640.80	5,097.12	36,737.92	72,816	1,09,553.92
T_9	28,000	4,640.80	6,497.12	39,137.92	92,816	1,31,953.92
T_{10}	28,000	5,640.80	7,897.12	41,537.92	1,12,816	1,54,353.92
T_{11}	28,000	3,635.00	5,089.00	36,724.00	72,700	1,09,424.00

APPENDICES

Appendix I. Agro-Ecological Zone of Bangladesh



Appendix II. Physical characteristics and chemical composition of soil of the experimental plot

Soil characteristics	Analytical results
Agrological Zone	Madhupur Tract
PH	5.6
Organic matter	0.45
Total N (%)	0.46
Available phosphorous	21 ppm
Exchangeable K	0.41 meq / 100 g soil

Source: Soil Resource and Development Institute (SRDI), Dhaka.

Appendix III. Monthly average record of air temperature, rainfall, relative humidity and Sunshine of the experimental site during the period from November 2014 to February 2015.

Month	Air temperature (°c)		Relative humidity (%)	Total rainfall (mm)	Sunshine (hr)
	Maximum	Minimum			
November, 2014	29.6	19.2	77	34.4	5.7
December, 2014	26.4	14.1	69	12.8	5.5
January, 2015	25.4	12.7	68	7.7	5.6
February, 2015	26.7	15.8	78	36.9	6.2

Source: Bangladesh Meteorological Department (Climate & Weather Division) Agargoan, Dhaka – 1212.