EFFECT OF NEB (NITROGEN EFFICIENCY FOR BIOAVAILABILITY) ON THE GROWTH AND YIELD OF MAIZE (*ZEA MAYS* L.)

A THESIS

BY

AFSANA AKTER

Student No. 1701057

Thesis Semester: July-December, 2023

MASTER OF SCIENCE (M.S.)

IN

SOIL SCIENCE

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY

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HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY

DINAJPUR-5200

JUNE, 2024

DEDICATED

TO MY

BELOVED FAMILY AND

TEACHERS

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June, 2024 The Authoress

ABSTRACT

Nitrogen Efficiency for Bioavailability (NEB) is now applied to maximize its uptake and decrease environmental impact by decreasing usage of urea fertilizer. It is a blend of natural root exudates, which helps to increase microbial activities in the soil. Using NEB, plants get more of the nitrogen for longer period of time which helps to give significant growth advantages of plants. An experiment was conducted in the research field of BWMRI, Dinajpur (AEZ 1) to find out the appropriate dose of NEB for maximizing the yield of maize. There were four treatments of NEB: a) Seed treatment with NEB @ 6ml/kg seed + NEB @1.5ml/L foliar application at 35 DAS, b) Seed treatment with NEB @6mL/kg seed + 1mL/L foliar application at 35 DAS, c) Seed treatment with NEB @6mL/kg seed + 1mL/L foliar application at 35 DAS + at 71 DAS, d) Seed treatment with NEB @ 6ml/kg seed + NEB @1.5ml/L foliar application at 35 DAS + at 71 DAS with Control (No NEB). BWMRI Hybrid Maize-2 was used as the test crop. The experiment was set up in a randomized complete block design (RCBD) with three replications. NEB treatments significantly affected the growth and yield contributing characters i.e., plant height at 98 DAS, plant height at 181 DAS, plants per hectare, cobs per plant, length per cob, cob diameter, lines per cob, grains per cob, grain weight per cob, cob fresh weight, 1000 grain weight etc. except leaves per plant, plants fresh weight, plants dry weight of maize plants. NEB treatments significantly affected the grain yield of maize plant. The highest grain yield (17.72 t/ha) was recorded in T_5 treatment, and the lowest grain yield (13.79 t/ha) was recorded in T_2 treatment. Grain yield increased by 17.43% in T_5 treatment compared to NEB control plots. This result suggests that seed treatment with NEB @ 6ml/kg seed + NEB @1.5ml/L foliar application at 35 DAS and 71 DAS is the appropriate dose for achieving higher yield of maize and reducing environmental hazards.

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LIST OF ABBREVIATIONS

AEZ	Agro-Ecological Zone
Agric.	Agriculture
Agril.	Agricultural
Agron.	Agronomy
Appl.	Applied
Biol.	Biology
Chem.	Chemistry
Cm	Centimeter
CV	Coefficient of Variance
DAS	Days After Sowing
Ecol.	Ecology
Environ.	Environmental
et al	et alii, And Others
Exptl.	Experimental
i.e.	id est (L), that is
J.	Journal
Kg	Kilogram
LSD	Least Significant Difference
M.S.	Master of Science
M^2	Meter squares
Mg	Milligram
NEB	Nitrogen Efficiency Bio-availability
NRE	Natural Root Exudates
Nutr.	Nutrition
Physiol.	Physiological

Res.	Research
RCBD	Randomized Complete Block Design
HSTU	Hajee Mohammad Danesh Science and Technology University
Sci.	Science
Soc.	Society
t ha-1	Ton per hectare
Viz	videlicet (L.), Namely
%	Percentage
@	At the rate of
Stat.	Statistics
Div.	Division

CHAPTER I

INTRODUCTION

Maize (*Zea mays* L.) is one of the major cereal crops under Poaceae family. It is one of the most common and popular cereal crops in Bangladesh. Maize is one of the world's leading crops ranked in the third position in the world cereal crop production after wheat and rice (FAO, 2018). Maize is grown commonly in almost all parts of our country and liked by the people, both poor and rich. Varieties also play an important role in crop yield. Two types of cultivars commonly being used are synthetic and hybrid cultivars. Maize hybrids play a pivotal role while deciding about the type and amount of fertilizer to meet the requirements for growth and development throughout the life span of the crop (Chandrashekra *et al.*, 2000; Khaliq *et al.*, 2008). It is rich in water and nutritional value. It contains protein 3.27g, lipid 1.35g, carbohydrate 18.7g, fiber 2g, total sugars 6.26g, vitamin C 6.8mg, starch 5.7g, calcium 2mg, choline 23mg and so on per 100g. Maize production has a great advantage that no serious pests (insects or diseases) have been reported on maize in the country. However, when the area and intensity of maize cultivation grow, this situation may change. As of now the absence of pests makes it easy to promote maize production.

Although maize is not a staple food cereal yet in Bangladesh, but presently it is the third most important cereal after rice and wheat. During 2022-23, 10.2 ton of maize was produced per hectare in Bangladesh (BWMRI, 2023). Maize production reached a record 4.55 million tons in the last FY, cultivated on over 0.5 million hectares of land across both winter and summer seasons, according to the Bangladesh Bureau of Statistics (BBS, 2024), whereas the annual grain requirement is about 7.0 million tons. Current national average yield of maize is 10.2 t/ha which is due to the introduction of hybrids and adoption of appropriate crop management practices. Demand of maize is increasing in Bangladesh day by day due to its' increasing demand for poultry, fish and animal feed and production of different types of processed foods and also for export. Bangladesh Wheat and Maize Research Institute (BWMRI) is entrusted to the research works for the improvement of wheat and maize in Bangladesh. Major thrust was given to develop high yielding wheat and maize varieties with resistance/tolerance to ranges of abiotic (heat, drought, salinity) and biotic (diseases) stresses and fitting well to the existing cropping systems. The growing demand of maize for feed market adds to its profitability as a crop. Yet, the 570,000 farmers in Bangladesh who grow maize meet only 70% of domestic demand. The low supply of produce is rooted in low quality inputs, limited knowledge, wrong cultivation techniques and post-harvest losses. Catalyst has been working in the maize sector since 2004. As maize has mainly been grown in the Northern regions of Bangladesh during the dry winter season, Catalyst together with seed companies started its intervention by supporting farmers with quality inputs, training and market access. In this context, contract farming was successfully introduced so that, by 2013, 55 contractors were collaborating with the seed companies and reaching more than 8,000 farmers. Since 2015, Catalyst started tackling the Southern disaster-prone coastal regions of Bangladesh, introducing summer and winter maize cultivation in areas where fallow land has resulted in low income for farmers. Simultaneously, farmers in some parts of the Northern region interested in growing maize in summer and winter season, have been supported with quality seeds and training.

In Bangladesh, farmers used huge amount of chemical fertilizers for the production of maize, as a result, production cost in increasing and at same time quality is decreasing. Nitrogen is an essential nutrient for maize and a key determinant of grain yield, particularly through its role in photosynthesis and other biological processes such as absorption of water and minerals, vacuole storage, and xylem transport. So, maize production and its quality may be increased by application of NEB (Nitrogen Efficiency for Bioavailability) which is natural root exudates, and which helps to supply nitrogen. NEB is an organic product with mineral or other components. NEB is a natural origin product, in liquid and dry forms, that are non-toxic and non- hazardous. NEB influences microbial population which makes nutrients more available. It influences mycorrhizae which collect, store and deliver nutrients directly to the plants.

Plant root exudates constitute up to 30 to 40% of the plants photosynthetic productivity (Samstevich, 1965). NEB contains a small amount of nutrients supplied by fertilizer to be used which results in superior yields. Root exudates are known to enhance growth rates of bacteria (Hartwig *et al.*, 1994) Plant roots release as much as 20% of them assimilates as root exudates in the form of organic acid, amino compounds, sugars and phosphate esters (Uren, 2001; whipps, 1990). Unseen parts of the plant secrets chemical compounds which acts as communication signal between the adjacent plant and microbial community present in the rhizosphere of the root. Root exudates correspond to an important source of nutrients for microorganisms in the rhizosphere and seem to participate in early colonization inducing chemotactic responses of rhizospheric bacteria (Bacilio *et al.*, 2004). The rhizosphere is defined as a zone of most intense bacterial activity around the roots of plant (Badri and Vivanco, 2009). Root exudate is one of the ways for plant communication to the neighboring plant and adjoining of microorganisms present in the rhizosphere of the root. The chemicals ingredients of the root exudates are specific to a particular plant species and also depend on the nearby biotic and abiotic environment. The chemical ingredients exuded by plant roots include amino acids, sugars, organic acids, vitamins, nucleotides, various other secondary metabolites and many other high molecular weight substances as primarily mucilage and some unidentified substances. Root exudate helps the plant to form partnerships with beneficial microbes and mycorrhiza. Plant encourages this partnership by secreting root exudates, which finally stimulate microbes and mycorrhiza. Root exudates mediate various positive and negative interactions like plant-plant and plant-microbe interactions.

NEB contains 17% Fulvic acid. Some importances of fulvic acid are given here: The fulvic-humic minerals can contribute to an increased exploitation of water by the plant. They have positive effects on plant DNA and RNA. It increases enzyme activity. It acts as catalyst in plant respiration/organic. The humic and fulvic acid for plants can enhance cell division and cell elongation. It increases drought tolerance and prevents wilting. It detoxifies various pollutants. It stimulates root development and increase plant growth. It increases plant membrane permeability during Autumn and Winter. It provides a food source for soil micro-organisms.

Nitrogen is an essential nutrient for maize and a key determinant of grain yield, particularly through its role in photosynthesis and other biological processes such as absorption of water and minerals, vacuole storage, and xylem transport. Plant encourages this partnership by secreting root exudates, which finally stimulate microbes and mycorrhiza. Root exudates mediate various positive and negative interactions like plant-plant and plant-microbe interactions. Though NEB has many positive effects, but research works on NEB with maize are very scarce in Bangladesh. This research will help in clear understanding of the effect of NEB on the nitrogen use efficiency of maize plant. This research was conducted to meet the following objectives:

1. To evaluate the effectiveness of NEB for maximum yield of maize.
2. To determinate the proper ratio of NEB for optimum yield of maize.

CHAPTER II

REVIEW OF LITERATURES

The relationship between nitrogen levels and crop yield has long been a subject of extensive research, and recent studies have delved into the specific impact of nitrogen on newly released maize hybrids. This comprehensive review aims to analyze the existing literature on the response of different levels of nitrogen on the yield and yield components of these cutting-edge maize hybrids.

2.1. Importance of Maize to future food security

The world area under maize cultivation was 177 M ha with 967 Mt production in 2013-14 and contributes almost 5% to world's dietary energy supply (Index Mundi, 2014). Recent projections by the International Food Policy Research Institute (IFPRI, 2003) indicate that by 2020 the demand for maize in all developing countries will overtake the demand for wheat and rice, with Asia accounting for nearly 60% of the global demand for maize (IFPRI, 2003). Half of the world maize is produced in the developing countries where maize flour is the staple food for the poor people while the maize stalk provide feed to their animals (Ofori *et al.*, 2004). The Eastern Gangatic Plains (EGP) (India, Bangladesh and Nepal) has very high yield potential of rabi and kharif-1 (spring) maize including Bihar, West Bengal (India), Bangladesh and Nepal Tarai (Ali *et al*., 2009). In Bangladesh, maize area and production increasing day by day with high speed because of increasing demand for poultry feed, fodder for animal and fish feed and starch industries in the region (BBS, 2015) and its grain are used for human consumption in mixture with wheat flour. It covers about 2834 ha of land with an annual production of 3000 metric tons (BBS, 1999). The farmers are also interested in growing it, so the crop has been included in the crop diversification programme (Kaul and Rahman, 1983).

2.2. Historical Perspective

Historically, nitrogen has been recognized as a crucial nutrient for plant growth and development. Early studies focused on understanding the general effects of nitrogen fertilization on maize crops (Adhikary *et. al.,* 2020). As technology advanced, researchers began to investigate how newly developed maize hybrids respond to varying nitrogen levels.

2.3 Maize Hybrid Development

The literature reveals a shift in focus towards newly released maize hybrids, emphasizing the importance of genetic advancements in crop breeding programs. These hybrids are designed to exhibit improved traits such as disease resistance, stress tolerance, and enhanced yield potential. Understanding how these hybrids interact with nitrogen levels is essential for optimizing agricultural practices (Khaliq *et al.*, 2009).

2.4 Nitrogen and Yield Components

Several studies have explored the impact of different nitrogen levels on various yield components of maize, including ear size, kernel weight, and overall crop yield (Eash *et al*., 2019). Findings suggest that the response to nitrogen varies among different hybrids, highlighting the importance of tailoring nitrogen application to specific genetic traits.

2.5 Nutrient Uptake and Utilization

The literature emphasizes the intricate relationship between nitrogen uptake and utilization by maize plants. Researchers have investigated the efficiency of nitrogen use in newly released hybrids, aiming to identify optimal nitrogen levels that maximize nutrient utilization and, consequently, crop yield (Eltelib *et al.,* 2006).

2.6 Environmental Considerations

Beyond crop yield, recent literature also addresses the environmental implications of nitrogen application. Balancing the need for increased yield with environmental sustainability is a growing concern. Studies have explored strategies for minimizing nitrogen runoff and environmental impact while still achieving high maize yields (Pires *et al.*, 2015).

2.7 Nitrogen Efficiency for Bioavailability (NEB) in relation to growth and yield of maize

Nitrogen Efficiency for Bioavailability (NEB) is now applied to maximize its uptake and decrease environmental impact by decreasing usage of urea fertilizer. It is a blend of natural Root Exudates, which helps to increase microbial activities in the soil. By the use of NEB, plants get more of the nitrogen for longer period of time which helps to give significant growth advantages of plants. Both fulvic acid (FA) and nitrogen (N) play important roles in agricultural production across the globe. Plants typically show a higher nitrogen utilization efficiency (NUE) under FA application (Yu *et al.*, 2023).

Although maize is not a staple food cereal yet in Bangladesh, but presently it is the third most important cereal after rice and wheat. During the winter season of 2022-23, 57.435 lac m ton of maize was produced from 5.191 lac ha of land and the average yield in the winter season is 11.060 t/ha. While, in the summer of 2022-23, 6.785 lac m ton of maize was produced from 0.867 lac ha of land and the average yield was 7.83 t/ha. If we considered both winter and summer, a total of 64.22 lac m ton maize was produced from 6.058 lac ha of land and two seasons average is 10.60 t/ha in the year 2022-23. However, the demand of maize is increasing in Bangladesh day by day due to its increasing demand for poultry, fish and animal feed and the production of different types of processed foods, and also for export. Bangladesh Wheat and Maize Research Institute (BWMRI, 2023) is entrusted with research works for the improvement of wheat and maize in Bangladesh. Nitrogen is used as the main nutrient for cultivating Maize. Urea is used as the source of Nitrogen. So due to the increasing trend of demand of Urea, every year Bangladesh imports 1-1.5 million tonnes of Urea fertilizer from abroad.

However, farmers are concerned about their high spending on Urea. So, they are using NEB which is a type of root extract which contains 17% Fulvic acid that helps to increase the number of soil microorganisms to save up to 50% Urea or Nitrogen (Geng *et al*., 2020; Yu *et al.,* 2023). NEB activates the beneficial microorganisms and fungi of plants' rhizosphere. Microorganisms preserve nitrogen in their body through immobilization process. When these microorganisms die, the organic nitrogen turns to acceptable form of plant through mineralization process. Plants take that nitrogen gradually (Yu *et al*., 2023).

Fulvic acid (FA) is the low molecular weight component of HA and is water-soluble. It not only increases the effects of seed dressing, root dipping and spraying but also stimulates root absorption (Canellas *et al.,* 2015). FA can promote seed germination and increase the seedling growth rate, and has a particular promoting effect on the development of the crop root system, which stimulates the seedling to root quickly, grow more secondary roots, and increase the amount of roots, and increases the ability of the crop to absorb water and nutrients (Dong *et al*., 2026; Yao *et al.*, 2019). The stimulating effect of FA on the aboveground part of crops led to vigorous growth, taller plant height and a strong stem, especially in the early stage, and FA stimulates the physiological metabolism of plant cells when it is absorbed through plant roots, which is manifested in increases in respiration and photosynthesis (Shang *et al*., 2017). The application of FA to the leaves of crops results in a reduction of stomatal opening and water transpiration, which might influence plant photosynthesis.

Nasreen and Islam (1990) also investigated the fertilizer effect on tomato yield and found that the yield response was linear with the levels of nitrogen and nitrogen application had certain optimum range beyond which the yield of tomato would not increase. Khattak *et al.*

(2001) studied the effect of different levels of nitrogen on the growth and yield of different cultivars of eggplant under the agro-climatic conditions of Peshawar. Effect of different nitrogen levels (0, 50, 75, 100, 125, 150 kg ha^{-1}) on aubergines *(Solarium melongena*) cultivars Black Bahar, Long Purple, Neelam Long and Special Black were studied at Agriculture Research Institute Tamab, Peshawar, Pakistan, in 2000. Different levels of nitrogen significantly increased number of branches, leaves and fruits/plant, stem thickness, plant height and yield at 125 kg nitrogen/ha, while minimum 10 values for these parameters were observed in different treatments. Maximum number of branches (7.84), leaves (285.380) and fruits/plant (13.67), stem thickness (1.19 cm) and yield (17674.91 kg ha^{-1}) were noted for the plants receiving 125 kg nitrogen/ha, while minimum number of branches (6.37), leaves (280.77) and fruits $plant^{-1}$ (11.08) were obtained in control treatment and minimum stem thickness (1.01 cm) and yield (14062.41 kg ha^{-1}) were found when 50 kg nitrogen ha^{-1} was applied.

Naidu *et al.* (1997) mentioned that the effects NPK fertilizers in combination with organic manures (farmyard manure, poultry manure and vermicompost) and biofertilizers (phosphate solubilizing bacteria and Azospirillum) on the growth and yield of aubergine cv. JB-64 were investigated during the rabi seasons of 1996/97, 1997/98 and 1998/99 in Jabalpur, Madhya Pradesh, India. Data were recorded for plant height, number of leaves per plant, number of branches per plant, fruit length, fruit girth, number of fruits per plant and fruit yield. NPK at 100:60:50 kg ha^{-1} + farmyard manure at 25 t/ha recorded the highest values for most parameters studied. NPK at 75:35:0 kg/ha + farmyard manure at 25 t/ha recorded the highest fruit girth and earliest 50% flowering. The highest mean fruit yield (161.62 q ha^{-1}) and net return (Rs. 24 140.50) were obtained with the former, while the highest benefit: cost ratio (2.212) was obtained with the latter treatment. The differences in yield and profitability between these treatments were not significant. Sharma (1995) reported that in tomato (cv. Pusa Ruby) the plant height, fruit number, seed yield plant-1 and seed yield/ha were increased with increasing rates of N. The highest yield of seeds was observed due to 120 kg N ha^{-1}.

Subramanian *et al.* (1993) stated that plant height and quality were increased with increasing rate of N application. They obtained the highest yield with 150 kg N/ha. The levels used were 0, 5, 100 and 150 kg ha^{-1}. Singh and Maurya (1992) reported that same trend of increasing rate of N application on brinjal plant. They obtained the best yield from 120 kg N ha^{-1}. The levels of nitrogen were 0, 60, and 120 kg N ha^{-1}.

By reviewing the different sources of information regarding the present experiment it was found and taken that the application of root exudates has the potential to response against different traits of maize and other crops. So, different doses of NEB in combination with different levels of chemical fertilizers were taken for the present study to observe the response on vegetative growth, yield and quality attributes of maize.

CHAPTER III

METERAIALS AND METHODS

A brief description about experimental, site, climatic condition, planting materials, treatments, experimental design and layout, crop growing procedure, intercultural operations, data collection and statistical analysis were described in this chapter. The details of experimental materials and methods are described below:

3.1 Experimental site & Soil

The experiment was set up at the soil science research field of Bangladesh Wheat and Maize Research Institute, Dinajpur, during the rabi season of 2022-23. The experimental site is located between 25.13 0 N latitude and 88.23 0 E longitudes and at an elevation of 37.5 m above sea level. The land belongs to the Old Himalayan Piedmont Plain (AEZ-I) (UNDP and FAO, 1988). The experimental field was medium-high land. The soil is Ranisankail sandy loam, a member of the hyperthermic aeric under the Inceptisol having only a few horizons, developed under an aquic moisture regime and variable temperature conditions. The morphological characteristics physical and chemical characteristics of the soil are presented in Table 3.1 & Table 3.2.

Table 3.1. **Morphological characteristics of experimental soil.**

Morphological Characteristics	
Location	Research field, BWMRI, Dinajpur 5200
AEZ	Old Himalayan Piedmont Plain (AEZ-1)
General soil type	Non-calcareous brown floodplain soil, acidic
Plant material	Piedmont alluvium
Soil series	Banashankari
Drainage	Well drained
Flood level	Above flood level
Land type	High land
Topography	Level

Table 3.2 Initial soil physical and chemical characteristics of the experimental field

Characteristics	**Value**
% Sand	59.68
% Silt	24.67
% Clay	15.65
Textural Class	Sandy Loam
pH	5.8
Organic Matter (%)	1.23
Total N%	0.14
Available P (ppm)	17.94
Exchangeable K (meq per 100g soil)	0.11
Available S (ppm)	16.7

3.2 Climate and soil

The experimental site provably most characterized by winter during the months from November to May with significant humid sub-tropical cropping zone which is characterized by scanty rainfall associated with moderately low temperature during Rabi season (October to March) and high temperature, high humidity, heavy rainfall with occasional gusty winds in Kharif season (April to September). Top soil was characterized by sandy loam in texture. These soils have very dark grey or black topsoil at a thickness of 25 cm or more which revealed that the color of the topsoil was dark grayish brown to dark yellowish brown and that of the sub soils was dark yellowish brown to light olive-brown and light brownish grey when moist. The soil of this region is well drained, and p^H is 5.8. The experimental area was flat and high topography which was available with an easy irrigation and drainage system.

3.3 Planting material

In this research work, the seeds of maize were used as planting materials. The maize variety used in the experiments was BWMRI Hybrid Maize 2. These seeds are collected from BWMRI, Nashipur, Dinajpur.

3.4 Treatments

The present experiment comprised of five different treatments of NEB in combination with urea and PKS fertilizers as follows:

T_1: NEB control

T_2: Seed treatment with NEB @ 6ml/kg seed + NEB @1.5ml/L or 750mL foliar application at 35 DAS

T_3: Seed treatment with NEB @6mL/kg seed + 1mL/L or 500mL foliar application at 35DAS

T_4: Seed treatment with NEB @6mL/kg seed + 1mL/L or 500mL foliar application at 35DAS + at 71DAS

T_5: Seed treatment with NEB @ 6ml/kg seed + NEB @1.5ml/L or 750mL foliar application at 35DAS + at 71DAS

3.5 Experimental design and layout

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The total numbers of unit plots were 15. The size of the unit plot was 5.0 m × 4.0 m. The spacing 60 cm × 20 cm was used under present study (Figure 1)

Figure 1: Layout of experimental plot (RCBD)

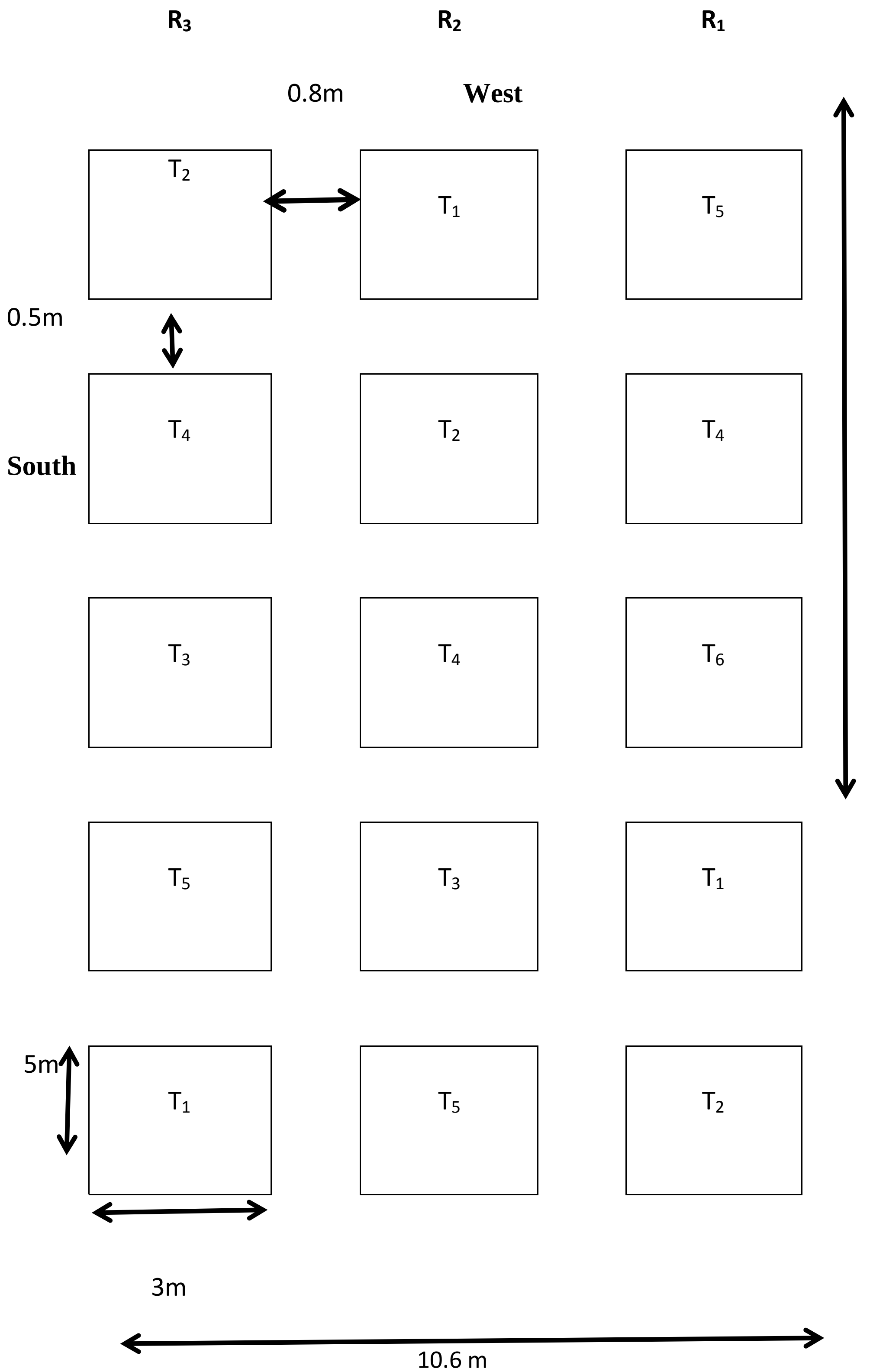

Figure 1: Layout of experimental plot (RCBD)

3.6 Collection and sowing of maize seeds

The seeds of maize variety developed by Bangladesh Wheat and Maize Research Institute (BWMRI) were collected from the BWMRI, Nashipur, Dinajpur.

3.7 Land preparation and sowing seeds

The land of the experimental site was first opened in the second week of November with power tiller and to obtain the desirable tilth the land was ploughed and cross-ploughed three or four times followed by laddering. Weeds and stubbles were removed from the corners of field using spade. The land was finally prepared on 19 November 2023. The seeds of Maize varieties were sown separately in the seed bed on 15 November 2023.

3.8 Fertilizer application

The crop was fertilized as per treatments and recommended dose (Table 3.3) of fertilizers. Normally urea was applied in three equal split installments with different levels of NEB. MoP was also added with two split doses.

Table 3.3 Fertilizer doses (BWMRI recommended)

Fertilizers	Doses
Cowdung	5000 kg/ha
Urea	550-600 kg/ha
TSP	300 kg/ha
MOP	350 kg/ha
$CaSO_4$	250 kg/ha
$ZnSO_4$	15 kg/ha
Boric Acid	8 kg/ha

3.9 Intercultural operations

After planting the seedlings, different intercultural operations were accomplished for better growth and development of the plants.

3.9.1 Gap filling

When the seedlings were established, the soil around the base of each seedling was pulverized.

3.9.2 Weeding

The plants were kept under careful observation. Weeding was done as and when necessary to keep the plots clean. It was required to keep the crop free from weeds and to keep the soil loose for proper aeration and for proper growth and development of maize plant. First weeding was done two weeks after emergence. Another weeding was done before 2nd top dressing of urea. Spading was done from time to time specially to break the soil crusts and keep the land weed free after irrigation.

3.9.3 Irrigation

Irrigations were given as and when necessary, by observing the soil moisture condition. Irrigation was given throughout the growing period. The first irrigation was given 20 days after planting followed by irrigation 30 days after the first irrigation, third irrigation was done at 70DAS. Top dressing of fertilizers was followed by irrigation for proper utilization of fertilizers.

3.9.4 Earthing up

Earthing up was done as and when required by taking the soil from the space between the rows.

3.10 Plant Protection

Fencing was done properly to protect the plants against animals.

3.10.1 Insect Pest

As a preventive measure against insect pests like Stem borer, Fall armyworm etc. Karate 2.5 EC @ 1 ml l^{-1}, virtako @ 1 ml l^{-1}, Lumectin @ 1 ml l^{-1} were applied to reduce the attack in the field. Many cleaning practices were also done to reduce the insect attack.

3.10.2 Diseases

Precautionary measures against various diseases of maize were taken. All possible phytosanitary measures were adopted to keep plant healthy.

3.11 Recording of data

Different types of data were collected based on the aims of the present study. Most of the parameters were taken after harvesting maize by using electronic balance and rest of the parameters were taken by using plastic scale, slide calipers and measuring tape and means were calculated by using a digital calculator. Treatment means were separated using the least significant difference (LSD) at the 5% level of significance. Economic analysis was conducted separately for each treatment. All expenses incurred on crop production, including land rent, seed, land preparation, fertilizer, and plant protection, were combined to get the total variable cost. Similarly, the gross return was calculated as per the market price of grain and straw. Lastly, the gross margin was computed with a difference of gross return and total variable cost. The benefits–cost ratio (BCR) of treatments was determined by the following formula:\

$$BCR = \frac{Gross\ return}{Total\ cost}$$

3.11.1 Yield attributes

The number of total leaves, branches per 5 plants per plot was recorded for maize varieties at and the average plant height was calculated.

3.11.1.1 Growth traits

i. Plant height (cm)

Five selected maize plants were considered for taking the plant height. Then the height of stems of five maize plants from each plot was taken at 98 DAS and 181 DAS and then means were taken in centimeter unit.

ii Days to first flowering

Days to first flowering of 5 plants per plot was recorded for BWMRI Maize 2 at 7 days' interval and the average number of total cobs plant^{-1} was calculated.

iii. Days to tassel initiation and full tassel emergence

All the plots were keenly observed daily to see the emergence of tassel from the tip of shoot and full emergence of tassel. The days to first tassel initiation and full tassel emergence was calculated by deducting the days to observing the first days of emergence and full tassel emergence from the days of seed sowing.

iv. Number of leaves plant^{-1}

Five selected plants of maize were considered for taking the leaf number. Then the total number of leaves of maize plant from each plot was added and then means were taken.

v. Number of cob initiating node plant^{-1}

Five selected plants of maize were considered for taking the number of cob initiating nodes. Then the total number of cob initiating nodes of maize plant from each plot was added and then means were taken.

vi. SPAD value of leaves

The relative content of leaf chlorophyll could be known from the SPAD value. So, SPAD-502 electrical device was used under present study which was manufactured by Minolta Camera Co., Ltd, Osaka, Japan. (1989). Five selected hills were taken to take the SPAD values and in all time the second leaf just beneath the top leaf was considered to take the

SPAD reading considering the 3 leaves from each selected maize plants. Then the mean of five hills was taken at 41 DAS, 60DAS, 76DAS, 105DAS, 149 DAS.

3.11.1.2 Yield traits

i. Days to silk initiation

All the plots were keenly observed daily to see the emergence of silk from the tip of shoot. The days to first silk initiation was calculated by deducting the days to observing the first days of emergence from the days of seed sowing.

ii. Number of cobs plant-1

Five selected plants of maize were considered for taking the number of cobs plant-1. Then the total number of cobs of maize plant from each plot was added and then means were taken.

iii. Length of cob

Five selected plants of maize were considered for taking the length of cobs. Then the length of cob of maize cob from each plot was added and then means were taken in centimeter.

iv. Unfilled length of cob

Five selected plants of maize were considered for taking the part of the cob length which was barren. Then the length of unfilled cob of maize cob from each plot was added and then means were taken in centimeter.

v Cob length

Length of cobs per 5 plants per plot was recorded for BWMRI Maize 2 variety. The average length of total fruits per plant was calculated.

vi Cob length diameter ratio

Length breadth ratio of 5 plants per plot was recorded. The average length diameter ratio of plant was calculated.

vii Grain yield (t ha^{-1})

The grain yield of cobs per 5 tagged plants per plot was recorded .The average weight of total cobs per plot was calculated.

viii 1000-Grain weight

Five cobs were selected from each plot were recorded for BWMRI Maize2 and the average 1000-seeds weight was calculated.

3.12 Statistical Analysis

The data on various parameters under study were statistically analyzed using MSTAT package program. The mean for all the treatments was calculated and analyses of variances for all the characters were performed by F-variance test. The significance of differences between pairs of treatment means was evaluated by the adjusted by using LSD (Least Significant Difference) at 5% and 1% level of probability.

CHAPTER IV

RESULTS AND DISCUSSION

4.1. Effect of NEB (Nitrogen Efficiency for Bioavailability) treatments on growth and yield contributing characters of maize

4.1.1 Plants per hectare

NEB treatments significantly affected the number of plants of maize plant. The highest number of plants/ha (77555) was recorded in T_4 treatment and the lowest number of plants/ha (69999) was recorded in T_2 treatment (Table 4.1).

4.1.2 Leaves per plant

There was no significant effect of NEB treatments on leaves per plant of maize plant. Highest average leaves per plant (10) was recorded in T_5 treatment (Seed treatment with NEB @ 6ml/kg seed with sequential application of NEB @1.5ml/L foliar application at 35DAS and at 71DAS) and lowest average leaves per plant (8.33) was recorded in T_4 treatment (Table 4.1). Vos and Biemond (1992) reported that the number of leaves, expansion rate of leaves, mature leaf area etc. are affected by nitrogen treatment.

4.1.3 Plant height at 98 DAS

NEB treatments significantly affected the plant height at 98 DAS of maize plant. Highest plant height (2.07 m) was observed in T_2 treatment (Seed treatment with NEB @ 6ml/kg seed in combination with NEB @1.5ml/L foliar application at 35DAS) and lowest plant height (1.91 m) was observed in T_4 treatment (Table 4) (Seed treatment with NEB @6mL/kg seed with sequential application of 1mL/L foliar application at 35DAS and at 71DAS) treatment.

Table 4.1 Growth of Maize as influenced by different levels of NEB

Treatments	Plants per hectare	Leaves per plant	Plant Height (98 DAS)	Plant Height (181 DAS)	Plants fresh weight (t/ha)	Plants dry weight (t/ha)
T1	71888.89bc	9.00	1.98bc	2.57a	28.80	10.996
T2	69999.99d	9.33	2.07a	2.45b	28.69	9.74
T3	70444.44cd	9.67	2.04ab	2.43b	28.58	9.30
T4	77555.55a	8.33	1.91d	2.40c	27.22	11.91
T5	74777.78b	10	1.93cd	2.45b	26.08	12.71
F-Test	***	NS	***	***	NS	NS
CV (%)	1.27	7.10	1.75	0.4782	3.74	13.15

Legends,
***, significant at 1% level of probability; NS, non-significant
T_1 : NEB control; $T_{2:}$ Seed treatment with NEB @ 6ml/kg seed + NEB @1.5ml/L or 750mL foliar application at 35 DAS; T_3: Seed treatment with NEB @6mL/kg seed + 1mL/L or 500mL foliar application at 35 DAS; T_4: Seed treatment with NEB @6mL/kg seed + 1mL/L or 500mL foliar application at 35 DAS + at 71 DAS; T_5: Seed treatment with NEB @ 6ml/kg seed + NEB @1.5ml/L or 750mL foliar application at 35 DAS + at 71 DAS

4.1.4 Plant height at 181 DAS

NEB treatments significantly affected the plant height at 181 DAS of maize plant. Highest plant height (2.57 m) was observed in T_1 treatment (NEB control) and lowest plant height (2.4 m) was observed in T_4 treatment (Table 4). Akande *et. al*. (2008) conducted a two-year field experiment in Institute of Agriculture Research and Training experimental field at Ibadan, Nigeria to evaluate the effects of NEB-33 fertilizer additive on the growth and yield of chilli pepper and results showed that treatments significantly (P>0.05) improved growth parameters and yield of chilli pepper.

4.1.5 Plants fresh weight

There was no significant effect of NEB treatments on fresh weight of maize plant. Highest fresh weight of plants (28.80 t/ha) was observed in T_1 treatment and lowest fresh weight of plants (26.08 t/ha) was observed in T_5 treatment (Table 4.1).

4.1.6 Plants dry weight

There was no significant effect of NEB treatments on fresh dry of maize plant. Highest dry weight of plants (12.71 t/ha) was found in T_5 treatment and lowest dry weight of plants (9.30 t/ha) was found in T_3 treatment (Seed treatment with NEB @6mL/kg seed in combination with 1mL/L foliar application at 35 DAS) (Table 4.1).

4.1.7 Cobs per plant

NEB treatments significantly affected the number of cobs per plant of maize plant. The highest average cobs per plant (1.16) was recorded in T_1 treatment and lowest average cobs per plant (1.02) was recorded in T_4 treatment. Agnieszka *et. al.* (2014) showed that fulvic acid (FA) improved plant growth and nutrient uptake under nutrient stress of maize plant. The effect of different FA application rates on maize growth and nitrogen utilization under low nitrogen stress was investigated by Agnieszka *et. al*. (2014). Iqbal *et. al.* (2011) reported that all the N levels, maize varieties and their interactions showed significant effects on plant growth and crop yield (Table 4.2).

4.1.8 Length per cob

NEB treatments significantly affected the length of cobs of maize plant. The highest average length per cob (19.07 cm) was observed in T_3 treatment and the lowest average length per cob (16 cm) was observed in T_4 treatment (Table 4.2).

4.1.9 Cob diameter

NEB treatments significantly affected the cob diameter of maize plant. Highest average cob diameter (17.88 cm) was observed in T_5 treatment and lowest average cob diameter (15.81 cm) was observed in T_2 treatment (Table 4.2).

Table 4.2 Yield component of Maize as influenced by different levels of NEB

Treatments	Cobs per plant	Length per cob	Cob diameter	Lines per cob	Cob fresh weight (t/ha)
T1	1.16a	18.12a	16.93b	18.00b	21.41b
T2	1.09b	18.71a	15.81c	16.33c	20.01b
T3	1.03cd	19.07a	16.07bc	16.67bc	19.95b
T4	1.02d	16.00b	16.15bc	16.67bc	19.25b
T5	1.04c	18.24a	17.88a	20.00a	25.11a
F-test	NS	***	***	***	***
CV (%)	0.9488	3.26	2.93	5.05	9.13

Legends,

***, significant at 1% level of probability; NS, non-significant

T_1 : NEB control; T_2: Seed treatment with NEB @ 6ml/kg seed + NEB @1.5ml/L or 750mL foliar application at 35 DAS; T_3: Seed treatment with NEB @6mL/kg seed + 1mL/L or 500mL foliar application at 35 DAS; T_4: Seed treatment with NEB @6mL/kg seed + 1mL/L or 500mL foliar application at 35 DAS + at 71 DAS; T_5: Seed treatment with NEB @ 6ml/kg seed + NEB @1.5ml/L or 750mL foliar application at 35 DAS + at 71 DAS

4.1.10 Lines per cob

NEB treatments significantly affected the number of lines per cob of maize plant. Highest average lines/cob (20.0) was recorded in T_5 treatment and lowest average lines/cob (16.33) was recorded in T_2 treatment (Table 5). Bakht *et.al.* (2007) conducted an experiment on maize and found that the effect of nitrogen level was significant for all parameters except number of cobs per plant, number of grains per cob and harvest index. But seed treatment with NEB increased the number of cobs per plant and number of grains per cob of maize plants significantly. Rahman *et. al*. (2016) also reported that nitrogen levels and plant spacing had significant effect on yield attributes and yield of Khaibhutta.

4.1.11 Cob fresh weight

NEB treatments significantly affected the fresh weight of cob of maize plant. The highest cob fresh weight (25.11 t/ha) was observed in T_5 treatment and the lowest cob weight (19.25 t/ha) was observed in T_4 treatment. Cob fresh weight increased by 17.28% in T_5 treatment compared to NEB control plots. Alsudays *et. al.* (2024) conducted an experiment on barley and found that enriching the soil with organic matter such as humic and fulvic acid to increase its content available nutrients, improves the chemical properties of the soil and increases plant growth as well as grain yield (Table 4.2).

4.1.12 Grains per cob

NEB treatments significantly affected the number of grains per cob of maize plant. The highest average number of grains per cob (545.67) was recorded in T_5 treatment and the lowest average number of grains per cob (521.33) was recorded in T_3 treatment (Table 4.3).

4.1.13 Grain weight per cob

NEB treatments significantly affected the weight of grains per cob of maize plant. The highest grain weight per cob (288.83 g) was observed in T_5 treatment and the lowest grain weight per cob (254.87 g) was observed in T_2 treatment (Table 6).

Table 4.3 Yield and yield components of Maize as influenced by different levels of NEB

Treatments	Grains per cob(no.)	Grain weight per cob (gm)	1000-grain weight (gm)	Grain yield (t/ha)
T1	526.67b	264.87ab	466.73b	15.09b
T2	522bc	254.87c	453.75c	13.79c
T3	521.33bc	257.24c	454.89c	14.12bc
T4	520.67c	258.48bc	456.63c	14.29bc
T5	545.67a	288.83a	477.86a	17.72a
LS	***	***	***	***
CV (%)	0.5987	1.49	5.35	4.23

Legends,

***, significant at 1% level of probability; NS, non-significant

T_1 : NEB control; $T_{2:}$ Seed treatment with NEB @ 6ml/kg seed + NEB @1.5ml/L or 750mL foliar application at 35 DAS; T_3: Seed treatment with NEB @6mL/kg seed + 1mL/L or 500mL foliar application at 35 DAS; T_4: Seed treatment with NEB @6mL/kg seed + 1mL/L or 500mL foliar application at 35 DAS + at 71 DAS; T_5: Seed treatment with NEB @ 6ml/kg seed + NEB @1.5ml/L or 750mL foliar application at 35 DAS + at 71 DAS

4.1.14 1000 grain weight

NEB treatments significantly affected the weight of 1000 grains of maize plant. The highest 1000 grain weight (477.86 g) was found in T_5 treatment and the lowest 1000 grain weight (453.75 g) was found in T_2 treatment (Table 5).

4.1.15 Grain yield

NEB treatments significantly affected the grain yield of maize plant. The highest grain yield (17.72 t/ha) was recorded in T_5 treatment, and the lowest grain yield (13.79 t/ha) was recorded in T_2 treatment (Table 6). Grain yield increased by 17.43% in T_5 treatment compared to NEB control plots. Sun *et. al.* (2020) reported that Biochar and fulvic acid amendments mitigate negative effects of coastal saline soil and improve crop yields in a three-year field trial of maize-barley rotation system. Similar findings also reported by

Moradi *et. al.* (2017) that fulvic acid increases seed yield and oil percentage of safflower. Yu *et. al.* (2023) also found that both fulvic acid (FA) and nitrogen (N) play important roles in maize production, plants typically show a higher nitrogen utilization efficiency (NUE) under FA application.

4.1.5 SPAD value of leaves:

SPAD value of maize recorded at 41DAS, 60DAS, 76DAS, 105DAS and 149DAS (Appendix II) did not differ significantly by different doses of NEB (Table 7). There was an increasing trend of leaf SPAD with the increasing of accumulation of leaf nitrogen up to certain doses and there after decreased.

Table 4.4 SPAD value of Maize as influenced by different levels of NEB

Treatments	SPAD (41DAS)	SPAD (60DAS)	SPAD (76DAS)	SPAD (105DAS)	SPAD (149DAS)
T1	47.17a	48.77ab	48.20b	57.93a	55.13a
T2	43.33a	47.47b	49.50ab	58.73a	49.03a
T3	47.93a	48.13ab	50.07a	57.60a	50.60a
T4	47.53a	49.03a	50.27a	59.47a	51.33a
T5	48.03a	49.50a	50.27a	58.60a	51.73a
LS	NS	NS	NS	NS	NS
CV (%)	5.35	1.52	1.74	2.47	6.85

Legends,

***, significant at 1% level of probability; NS, non-significant

T_1 : NEB control; $T_{2:}$ Seed treatment with NEB @ 6ml/kg seed + NEB @1.5ml/L or 750mL foliar application at 35 DAS; T_3: Seed treatment with NEB @6mL/kg seed + 1mL/L or 500mL foliar application at 35 DAS; T_4: Seed treatment with NEB @6mL/kg seed + 1mL/L or 500mL foliar application at 35 DAS + at 71 DAS; T_5: Seed treatment with NEB @ 6ml/kg seed + NEB @1.5ml/L or 750mL foliar application at 35 DAS + at 71 DAS

At 41DAS, the highest SPAD value was found from T5 (48.03) treatment whereas which was statistically similar to T3 (47.93) treatment and T4(47.53) treatment and the lowest found from T2 (43.33) treatment. At 60DAS the highest SPAD value was found from T5 (49.50) treatments whereas the lowest from T8 (45.11) treatment. At 76 DAS the highest SPAD value was found from T5 (50.27) treatment which was statistically similar to T3 (47.93) treatment whereas the lowest from T1 (48.20) treatment. At 105DAS the highest SPAD value was found from T4 (59.47) treatment whereas the lowest from T1 (57.93) treatment. At 149DAS the highest SPAD value was found from T1 (55.13) treatment whereas the lowest from T2 (49.03) treatment.

CHAPTER V

SUMMARY, CONCLUSION AND RECOMMENDATION

The experiment was conducted in the research field of Bangladesh Wheat and Maize Research Institution, Dinajpur-5200, during 19 November 2023 to June, 2024. The land belongs to AEZ 1 i.e., Old Himalayan Piedmont Plain. The land was moderately well-drained with a sandy loam texture and the climatic condition of the area was sub-tropical. In the study, there were four treatments of NEB (Nitrogen Efficiency Bioavailability) - Seed treatment with NEB @ 6ml/kg seed + NEB @1.5ml/L or 750mL foliar application at 35DAS, Seed treatment with NEB @6mL/kg seed + 1mL/L or 500mL foliar application at 35DAS, Seed treatment with NEB @6mL/kg seed + 1mL/L or 500mL foliar application at 35DAS + at 71DAS, Seed treatment with NEB @ 6ml/kg seed + NEB @1.5ml/L or 750mL foliar application at 35DAS + at 71DAS with Control (No NEB). BWMRI Hybrid Maize-2 was the test crop.

The experiment was set up in a randomized complete block design (RCBD) with three replications. The plot size was 5m×4m. Each plot received manure and fertilizer at the rate of 333.33 kg cowdung, 36.67-40 kg urea, 20 kg TSP, 23.33 kg MoP, 16.67 kg calcium sulfate, 1 kg zinc sulfate and 0.53kg boric acid per hectare. Full amount of all fertilizers expect urea was applied during final land preparation. The urea was applied in three equal splits. Different intercultural operations such as weeding and irrigation were done to ensure normal growth of the plant. All intercultural operations were same for all the plots.

There was a significant effect of NEB treatments on the growth and yield contributing characters of maize plants. NEB treatments significantly affected the growth and yield contributing characters i.e., plant height at 98 DAS, plant height at 181 DAS, plants per hectare, cobs per plant, length per cob, cob diameter, lines per cob, grains per cob, grain weight per cob, cob fresh weight, 1000 grain weight etc. of maize plants. The highest cob fresh weight (25.11 t/ha) was observed in T_5 treatment and the lowest cob weight per cob (19.25 t/ha) was observed in T_4 treatment. Cob fresh weight increased by 17.28% in T_5 treatment compared to NEB control plots. Leaves per plant, plants fresh weight, plants dry weight etc. parameters were not significantly affected by NEB treatments. Highest fresh weight of plants (28.80 t/ha) was observed in T_1 treatment and lowest fresh weight of plants (26.08 t/ha) was observed in T_5 treatment. NEB treatments significantly affected the grain yield of maize plant. The highest grain yield (17.72 t/ha) was recorded in T_5 treatment and the lowest grain yield (13.79 t/ha) was recorded in T_2 treatment. Grain yield increased by 17.43% in T_5 treatment compared to NEB control plots.

Thus, it can be concluded that seed treatment with NEB @ 6ml/kg seed + NEB @1.5ml/L foliar application at 35 DAS and 71 DAS is the appropriate dose for recommendation to achieve maximum effectiveness of NEB and optimum yield of maize.

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APPENDICES

Appendix I

ANOVA for all growth and yield parameters

Parameters	P values		Standard Errors		Mean
	Replication	Treatment	Replication	Treatment	
Plant height at 98 DAS	0.7156	0.0025**	0.0219	0.0283	1.99
Plant height at 181DAS	0.2289	0.0000***	0.0074	0.0096	2.46
Leaves/plant (no.)	0.1114	0.0972NS	0.4163	0.5375	9.27
Plants/ha (no.)	0.3137	0.0000***	586.26	756.86	72933.33
Cobs/plant	0.4670	0.0000***	0.0064	0.0083	1.07
Plants fresh weight (t/ha)	0.6678	0.4168ns	0.6701	0.8651	28.35
Plants dry weight (t/ha)	0.5844	0.0889ns	0.91	1.17	10.93
Length/cob (cm)	0.5854	0.0017**	0.3720	0.4803	18.03
Cob/diameter (cm)	0.2452	0.0046**	0.3073	0.3967	16.57
Lines/cob (no.)	0.3765	0.0049**	0.5598	0.7226	17.53
Grains/cob (no.)	0.1032	0.0000***	2.00	2.58	527.27
Grain wt./cob (gm)	0.4282	0.0097**	2.46	3.18	260.96
Cob fresh weight (t/ha)	0.9373	0.0347**	1.22	1.58	21.15
Grain yield (t/ha)	0.2930	0.0004***	0.4012	0.5179	15.00
1000 grain weight (gm)	0.2306	0.0017**	3.21	4.14	461.97

Legends,
***, significant at 1% level of probability; NS, non-significant
T_1 : NEB control; $T_{2:}$ Seed treatment with NEB @ 6ml/kg seed + NEB @1.5ml/L or 750mL foliar application at 35 DAS; T_3: Seed treatment with NEB @6mL/kg seed + 1mL/L or 500mL foliar application at 35 DAS; T_4: Seed treatment with NEB @6mL/kg seed + 1mL/L or 500mL foliar application at 35 DAS + at 71 DAS; T_5: Seed treatment with NEB @ 6ml/kg seed + NEB @1.5ml/L or 750mL foliar application at 35 DAS + at 71 DAS

Appendix II

Growth and yield parameters of maize as influenced by different levels of NEB

Parameters	Treatments					CV%	F-test
	T1	T2	T3	T4	T5		
Plant Height (98 DAS)	1.98bc	2.07a	2.04ab	1.91d	1.93cd	1.75	***
Plant Height (181 DAS)	2.57a	2.45b	2.43b	2.40c	2.45b	0.4782	***
Leaves/plant	9.00	9.33	9.67	8.33	10	7.10	NS
Plants/ha	71888.89c	69999.99d	70444.44cd	77555.55a	74777.78b	1.27	***
Cobs/plant	1.16a	1.09b	1.03cd	1.02d	1.04c	0.9488	***
Plants fresh weight (t/ha)	28.80	28.69	28.58	27.22	26.08	3.74	NS
Plants dry weight(t/ha)	10.996	9.74	9.30	11.91	12.71	13.15	NS
Length/cob	18.12a	18.71a	19.07a	16.00b	18.24a	3.26	***
Cob diameter	16.93b	15.81c	16.07bc	16.15bc	17.88a	2.93	***
Lines/cob	18.00b	16.33c	16.67bc	16.67bc	20.00a	5.05	***
Grains/cob(no.)	526.67b	522bc	521.33bc	520.67c	545.67a	0.5987	***
Grain wt./cob (gm)	264.87ab	254.87c	257.24c	258.48bc	288.83a	1.49	***
Cob fresh wt. (t/ha)	21.41b	20.01b	19.95b	19.25b	25.11a	9.13	***
Grain yield (t/ha)	15.09b	13.79c	14.12bc	14.29bc	17.72a	4.23	***
1000-grain wt. (gm)	466.73b	453.75c	454.89c	456.63c	477.86a	5.35	***

Legends,

***, significant at 1% level of probability; NS, non-significant

T_1 : NEB control; $T_{2:}$ Seed treatment with NEB @ 6ml/kg seed + NEB @1.5ml/L or 750mL foliar application at 35 DAS; T_3: Seed treatment with NEB @6mL/kg seed + 1mL/L or 500mL foliar application at 35 DAS; T_4: Seed treatment with NEB @6mL/kg seed + 1mL/L or 500mL foliar application at 35 DAS + at 71 DAS; T_5: Seed treatment with NEB @ 6ml/kg seed + NEB @1.5ml/L or 750mL foliar application at 35 DAS + at 71 DAS

Appendix III

ANOVA for SPAD value recorded at different days after sowing (DAS)

SPAD Value	P values		Standard Errors		Mean
	Replication	Treatment	Replication	Treatment	
41 DAS	0.9279	0.2125NS	1.58	2.05	46.80
60 DAS	0.4450	0.0627	0.4664	0.6021	48.58
76 DAS	0.8516	0.0822	0.5457	0.7045	49.66
105 DAS	0.3138	0.5774	0.91	1.18	58.47
149 DAS	0.1994	0.3768	2.23	2.88	51.57

Legends,

DAS= Days After Sowing ,ANOVA= Analysis of variance,SPAD=Soil Plant Analysis Development)

***, significant at 1% level of probability; NS, non-significant

T_1 : NEB control; $T_{2:}$ Seed treatment with NEB @ 6ml/kg seed + NEB @1.5ml/L or 750mL foliar application at 35 DAS; T_3: Seed treatment with NEB @6mL/kg seed + 1mL/L or 500mL foliar application at 35 DAS; T_4: Seed treatment with NEB @6mL/kg seed + 1mL/L or 500mL foliar application at 35 DAS + at 71 DAS; T_5: Seed treatment with NEB @ 6ml/kg seed + NEB @1.5ml/L or 750mL foliar application at 35 DAS + at 71 DAS

Some Pictorial View of the Experiment


WEIGHT (KG)
UNIT PRICE (TK/KG)
TOTAL (TK)
7 8 9 C
4 5 6 ADD
1 2 3 ZERO
0 . PCS TARE
M1 M2 CHG
AC