IMPACT OF FERTILIZER AND AZOTOPEX - AC ON LEAF BLIGHT DISEASE AND GROWTH ATTRIBUTES OF WHEAT

A thesis

By

MITA SAHA PUJA

Student No. 1701405

Semester: January- June, 2024

Session: 2023-2024

MASTER OF SCIENCE (M.S.)

IN

PLANT PATHOLOGY

DEPARTMENT OF PLANT PATHOLOGY

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY, DINAJPUR-5200

JUNE, 2024

IMPACT OF FERTILIZER AND AZOTOPEX - AC ON LEAF BLIGHT DISEASE AND GROWTH ATTRIBUTES OF WHEAT

A thesis

By

MITA SAHA PUJA
Student No. 1701405
Semester: January- June, 2024
Session: 2023-2024

Submitted to the

Department of Plant Pathology

Hajee Mohammad Danesh Science and Technology University

in partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE (M.S.)
IN
PLANT PATHOLOGY

DEPARTMENT OF PLANT PATHOLOGY

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY

UNIVERSITY, DINAJPUR-5200

JUNE, 2024

IMPACT OF FERTILIZER AND AZOTOPEX - AC ON LEAF BLIGHT DISEASE AND GROWTH ATTRIBUTES OF WHEAT

A thesis

By

MITA SAHA PUJA

Student No. 1701405

Semester: January- June, 2024

Session: 2023-2024

Approved as to the style and content by:

____

Professor Dr. Sheikh. Md. Mobarak Hossain

Supervisor

____

Professor Dr. A.T.M Shafiqul Islam

Co-supervisor

____

Professor Dr. Md. Mohidul Hasan

Chairman, Examination Committee &

Chairman, Department of Plant Pathology

DEPARTMENT OF PLANT PATHOLOGY

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY, DINAJPUR-5200

JUNE, 2024

Dedicated
To my
Beloved Parents

ACKNOWLEDGEMENT

All praises to almighty and kind full "God "who enabled me to pursue my higher study and to complete the research work and to submit the thesis for the degree of master of science (M.S.) in Plant Pathology, Hajee Mohammad Danesh Science and Technology, Dinajpur, Bangladesh. Words actually will never be enough to express how grateful I am, but nevertheless I shall try my level best to express my gratefulness to some people.

It's a pleasure to convey my heartiest gratitude and greeting to my honorable supervisor ***Prof. Dr. Sheikh. Md. Mobarak Hossain****, Department of plant pathology, Hajee Mohammad Danesh Science and Technology. I deeply appreciate his cooperation, advice, and guidance in preparing this report.*

It's gives me most pleasure and honor to convey my sincere gratitude and appreciation to my respected co-supervisor ***Prof. Dr. A.T.M Shafiqul Islam****, Department of Plant Pathology, Hajee Mohammad Danesh Science and Technology for his valuable guidance, support, encouragement and co-operation throughout the duration of my studies.*

Cordial Thanks and honor to ***Professor Dr. Md, Mohidul Hassan Chairman, Professor S.M. Emdadul Hasan. Professor Dr. Md. Mamunur Rashid, and Assistant Professor Md. Mukul Islam, Lecturer Md. Mobinul Islam and Md. Ahsan Habib****, Department of Plant Pathology, Hajee Mohammad Danesh Science and Technology for their valuable suggestions and motivations during the period of the study.*

I am lucky, god gives me good friends as like ***Abu Raihan*** *and* ***Kawser Jahan Tania****. They always inspire, encourage patience, sacrifice during the study period. I am also thankful to my classmates, juniors, seniors and all the stuffs for support and generous assistance.*

Finally, I would like to take the opportunity to express my heartfelt appreciation and indebtedness to my beloved ***Parents, Husband (Gopal Saha), Family members*** *well wishes for their inspiration, patience, encouragement, and sacrifice during the entire period of the study.*

ABSTRACT

BARI GOM-33 is a high-yielding variety of wheat that can respond to fertilizer combinations and biological approaches. The leaf blight of wheat caused by *Bipolaris sorokiana* is now a great threat for wheat cultivars in warm and humid regions of the world. Randomized complete block design (RCBD) with four replications is used in this experiment. Four treatments are, viz., T_1 = 100% FRG recommended doses(control); T_2 = FRG recommended dose (40% urea + 100% TSP + 100% MoP) + Azotopex-AC; T_3 = FRG recommended dose (75% urea + 100% TSP + 100% MoP) + Azotopex-AC; T_4=FRG recommended dose (60% urea + 100% TSP + 100% MoP) + Azotopex-AC; and T_5 = farmer's practice (Urea-650g, TSP-550g, MoP-450g, Zipsum-300g, Magnesium and Boron-30g) were evaluated against Azotopex-AC was used in this experiment. Additionally, the lowest quantity of black-pointed seed was detected in T_2. This study suggested that the combined application of fertilizers with Azotopex-AC shown good result against leaf blight of wheat. And growth attributes of wheat are also improved. T_4 was observed to be the best in terms and yield attributing characters compared to other treatments.

CONTENTS

LIST OF TABLES

LIST OF FIGURE

LIST OF ABBREVIATIONS

AEZ : Argo Ecological Zone

DAS: Days After Sowing

DS : Disease severity

LSD : Least Significance Difference

PLP : Plant Pathology

RCBD : Randomized Complete Block Design

CHAPTER 1

INTRODUCTION

The world's most important cereal crop is wheat (*Triticum aestivum L.*) and it is used as staple food by two third of the world's population. In Bangladesh wheat is considered as the second most staple food crop next to rice (Majumder, 1991). For people's diets it is a great source of plants protein (James and Mauseth, 2018). About 8% to 16% protein content are present in wheat grain which is playing a crucial role in determining the end-use quality of wheat products. (Herbert wieser, 2020) Wheat grains and flours are used as raw materials for the manufacture of countless food a feed product. Bread, pasta, noodles, cake these ready to eat products are made from wheat (Herbert wieser, 2020).

Wheat (*Triticum aestivum*) is an essential food crop and winter wheat constitute about 80% global production of wheat (Franch *et al.*, 2015).

Because of rapid population growth and disruptions to virtually all agricultural activities during the War of Liberation in 1971 and also various natural disasters, such as floods, droughts, cyclones requirement of wheat was increase (Index Mundi 2012a, Sobhan 1979; Alamgir 1980; Sen 1982; Hugo 2006).

Rice alone could not meet the food requirements of the country at that time, it was realized that than (Banglapedia 2006). As an alternative winter food crop wheat was therefore chosen ('Sonora 64' and 'Penjamo 62') two Mexican varieties were tested first in the northern part of Bangladesh in 1965 (BARI 2010).

A 3-year (2008–09 to 2010–11) examination by O'Brien (2011) indicated that to ensure local demand Bangladesh imported 3.1 million metric tons of wheat each year. In 1975, by utilizing Index Mundi (2012b) stated that initially, 4000 tons of 'Sonalika' and 'Kalyansona' seeds were imported from India and distributed to farmers (BARI 2010). Wheat provides the most calories and protein for the global food supply (Cai 2019). Wheat provides 20% of the protein and 21% of the food calories for more than 4.5 billion people in 94 countries and nutritionally more rich food than rice with protein content of 12% as against 8% in rice (Singh *et al.,* 2004). As wheat grains are highly nutritive, they are rich in energy, carbohydrates, dietary fiber, fat, protein, thiamine, riboflavin niacin, pantothenic acid, vitaminB6, folate, calcium, iron, magnesium, phosphorus, potassium, zinc, and manganese (USDA, 2006). According to USDA (United States Department of Agriculture) compute that in 2023/2024 wheat production will be 783.43 million metric tons. In wheat production a decrease of 6.06 million tons or 0.77% around the globe.

Pest and diseases cause loss on average, about 20% of the global wheat production every year. These losses amounted to about 140 million tons, equivalent to about $35 billion in 2012, (Anonymous, 2014).

The top ten of the most important fungal pathogens are ranked among like rusts (*Puccinia* sp.), Septoria leaf blotch (*Septoria* spp.), powdery mildew (*Blumeria graminis*) and *Fusarium* species (Dean *et al.,* 2012). Leaf rust (*Puccinia triticina*), Blight (*Biporaris* *sorokiniana*), smut, blast, Spot blotch, virus disease, soil borne, seed borne diseases cause yield loss in wheat very much. As many as 26 seed borne pathogens causing 14 seed borne diseases in wheat and it causes several losses in wheat (Shamim, *et al.,* 2009). Among them *Bipolaris sorokiana* is a serious concern in Bangladesh which causes leaf blight, spot bloch, & black point (Shamim *et al.,* 2009). In case of soil borne vectors, inefficient & growing of resistant cultivars is the only way of ensuring wheat cultivation in the growing area of infested fields. The most important fungal diseases of wheat & the possibilities of reducing yield losses care briefly described (Bockus *et al.,* 2010). To reduce the pathogen infection fungicide is used. Application of fungicide depends on right time, grain price, fungicide costs, (Lopez *et al.*, 2015). But fungicide has some hazardous effect in the crop & environment. It has residual effect it makes pathogen resistance to specific fungicide. Sometimes fungicides have health hazards to human & animal. Now a days, it is important to use eco-friendly or organic pesticide to reduce pathogen infection. One option to avoid yield losses caused by these pathogens is the application of fungicides. However, fungicides show resistance or tolerance by the repeated use of fungicides induces a considerable selection pressure on respective pathogens, in *B. graminis*, *Septoria* spp. Or *Fusarium* spp. which has been already detected (Becher and Wirsel, 2012).

At different environment under variable ecological conditions, interest in the beneficial rhizobacteria associated with cereals has increased recently and several studies clearly demonstrated the positive and beneficial effects of Azotopex-AC on growth and yield of different crops especially wheat (Ozturk *et al.*, 2003).

Nitrogen-fixing bacteria is very essential in non-leguminous crop, e.g., rice and wheat farming systems Biological nitrogen fixation are important because it is an inexpensive source of nitrogen for higher yields (Muhammad Ali, 2008).

Use Of the plant growth regulator aims to prevent pesticide residues in wheat, avoid negative impacts on wheat growth and development and reduce environmental pollution, ultimately preventing production distortion (Liu Peng, *et al.*, 2019).

In view of the facts, the present study was undertaken to detect the effectiveness of Azotopex-AC on wheat and controlling leaf blight of wheat, as a trial version,

OBJECTIVES:

i. To evaluate the impact of different fertilizer and Azotopex-AC *on* wheat growth attributes.
ii. To observe the effectiveness of fertilizer combinations and Azotopex-AC on leaf blight disease in wheat.

CHAPTER 2

REVIEW OF LITERATURE

Zaman *et al.* (2010) experimented that when apparently healthy seeds were treated with Bavistin 50WP, the highest seed germination and lowest incidence of *Bipolaris sorokiniana* were observed. Farmers that preserved seed consistently saw a greater frequency of *Bipolaris sorokiana* and much reduced seed germination. *Bipolaris sorokiniana* incidence was decreased and seed germination was greatly enhanced by all of the environmentally friendly seed treatments.

Panna *et al.* (2009), found that the easiest way to manage this disease is to use seed that is free of pathogens.

Rahman *et al.* (2009) carried out an experiment developed an integrated strategy for managing the wheat foot and root rot and *Bipolaris* leaf blight (BpLB) pathogens in field conditions throughout the 2007–2008 cropping season. In order to manage Bipolaris leaf blight and foot and root rot diseases of wheat caused by *Bipolaris sorokiniana* and *Sclerotium rolfsii* or *Rhizoctonia solani*, respectively, he used chemical fertilizer alone in combination with soil treatment (poultry refuse) and fungicide (Tilt 250EC). He discovered that the treatment where N was not applied at all resulted in the lowest plant height, spokes/m2, grains/spike, and grain yield

Paradeshi *et al.* (2008) observed that during grain filling or the milking stage, wheat grains are vulnerable to infection against Leaf Blight of wheat.

Singh *et al.* (2012) stated that wheat diseases include blotches and leaf blight. At crop maturity, *Bipolaris sorokiana* and *Alternaria triticina* had average incidences of 62% and 43%, respectively; however, in April, *Alternaria triticina* displayed an average incidence of 14.4%.

Sharma and Duveiller (2007) conducted an experiment using a cropping system of rice and wheat. He discovered that in 2004 and 2005, the severity of leaf blight increased to 100% and 70%, respectively.

Ahmed *et al.* (2007) stated that in wheat variety, tilt-250 EC (0.1%) sprayed plots yielded 36% more grain than unsprayed plots (Sonalica).

According to Bhandari et al. (2003), 30 genotypes of promising wheat were assessed in a lab setting. The findings indicated that the genotypes BL1724, BL1868, NL781, and Chirya-3 had less than 10% *B. sorokiniana* infection in their seeds.

Zobaer *et al.* (2007) found that applying hot water to seemingly healthy wheat seedlings for five minutes at 520 degrees Celsius considerably lessened the severity of leaf spots on the wheat compared to the control.

Islam *et al.* (2006) reported that vitavax-200 with eight plant extracts to cure wheat leaf spot (Bipolaris sorokiana). Of the eight plant extracts tested, the extracts from onion, garlic, Kalijira, ginger, Biskatali, and neem displayed a grain yield that was statistically comparable to the vitavax-200 seed treatment.

Reza *et al.* (2006) applied an experiment to analyze the impact on wheat of varying degrees of *Bipolaris sorokiniana* plant and seed infection. He demonstrated that the highest recorded percentage of seed rot/seedling mortality was 15.73%, with a subsequent severity of leaf blight of 75.4%.

Shahidullah (2006) carried out an experiment against *Bipolaris* leaf blight of wheat. He reported that Tilt-250EC showed the greatest efficacy against the illness, reducing the PDI value by 72% and increasing grain production by more than 108% compared to the control.

Ozer (2005) showed that black point has been linked to several fungal species that produce large yields, including *Alternaria, Bipolaris, Fusarium, Cladosporium,* and *Sclerotium.*

Sharma-Poudyal *et al.* (2005) carried out an experiment in order to ascertain the impact of seed treatment. The foliar fungicides lessened the severity of HLB and enhanced grain yield. The greatest increases in grain yield over the control were 38% in 2002 and 83% in 2003 as a result of fungicide spraying.

Malakar (2003) proved that black pointed seeds had a negative impact on post-emergence mortality, *B. sorokiniana* disease severity, incidence of black mold, and the emergence of seedlings, seedling vigor, plant growth, and grain yield.

Hossein (2002) stated that in comparison to farmers conserved seed office (cv.BR11), grain production was enhanced by 16.62%, 16.45%, 23.39%, and 26.60% for farmers clean seed, washed farmers seed, and seed treated with Vitavax-200.

Nagarangan and Kumar (1998) examined that *Bipolaris sorokiniana* is the cause of the foliar leaf blights that affect wheat, and it has been reported that the disease can harm plants as early as the primary leaf stage and makes them more prone to flowering.

Singh *et al.* (1998) proved that reduced leaf blight incidence when wheat was sown in the fourth week of November as opposed to wheat that was sown later.

Mondol (2000) stated that a possible cause of *B. sorokiniana* survival, which leads to wheat spot blotch development, seedling death, and germination failure, could be contaminated seeds and soil that have either colonized grains or conidial suspension.

Shabeer and Bockus (1998) showed that maximum yield losses for inoculations during the boot and blooming periods, suggesting that those were the stages at which plants were physiologically most vulnerable to losses. Grain weight and quantity were significantly reduced, which led to losses.

Alam *et al*. (1994) examined presently the most common wheat disease in Bangladesh is *Bipolaris* leaf blight. As seedlings become older, the illness becomes more prevalent. This disease is somewhat sensitive to almost all commercial cultivars.

Rashid *et al*. (1994) found that the connection between seed quality and the prevalence of leaf blight. They claimed that, in field settings, the occurrence of *B. sorokiniana* leaf blight is positively correlated with the decline in seed quality.

Hossain and Azad (1992) stated that higher age of crop plant resulted higher incidence of leaf spot (*B sorokiniana*.).

Sultana and Rashid (2012) carried out an experiment to find out how *Bipolaris sorokiniana* affects the germination of wheat seeds in in vitro conditions. Examples of these kinds of wheat seeds include healthy-looking, black-pointed, and shriveled. From 2010 to 2012, the experiment was carried out in the Seed Pathology Centre laboratory at Bangladesh Agricultural University in Mymensingh.

Kumar *et al.,* (2014), Stated that free-living soil bacteria known as "plant growth-promoting *Rhizobacteria*" actively invade the rhizosphere, or plant roots, and when administered to seeds or crops, they increase plant growth and yield.

EL-zawawy *et al*. (2023) stated that *Azotobacter* is an important component in wheat production because it increases growth and productivity. According to research, certain strains of *Azotobacter*, such as Az. *chroococcum* and Az. *vinelandii*, produce vital plant hormones such auxins, gibberellins, and cytokinins. These hormones cause an increase in wheat plant height, spike number, grain weight, chlorophyll content, and nitrogen levels.

Gawhara *et al.* (2022) concluded that wheat yield is greatly increased when nitrogen fertilization and *Azotobacter* inoculation are combined. Applied nitrogen levels are reduced by 25% while growth characteristics and yield metrics are increased.

Vijay Kumar *et al.* (2019) carried out an experiment and stated that due to its capacity to produce growth regulators, fix nitrogen, encourage rhizospheric bacteria, and enhance nutrient uptake, *Azotobacter* is a useful substitute for chemical fertilizers and promotes soil health and sustainable agriculture.

Mokula Mohammed Raffi *et al.* (2021) find out that nitrogen-fixing bacteria like *Azospirillum* have been extensively studied for their growth-promoting effects on cereal crops, including wheat, showcasing the importance of microbial inoculants in enhancing agricultural productivity.

Soleiman *et al.* (2022) concluded that the effect of fustigation of Humic acid (HA) and *Azotobacter* chroococcum UT1 (AZ) on nutrient elements (P, K, Zn, Fe, Mn and Cu), dry gluten, protein and essential amino acids of two wheat cultivars (Chamran and Kouhdasht), comparing four treatments (control, HA, AZ and HA× AZ) using randomized complete block design with four replicates was conducted at the research station of Chardavol in Iran as mentioned in this paper. Results from two years of data showed that the combined application of HA and AZ significantly improved nutrient elements, dry gluten, protein concentration, and essential amino acids in both wheat cultivars compared to the control

MeCarty Sc *et al.* (2017) carried out an experiment and stated that results showed that plant height, number of tillers/plants, number of spikes/ plants, spike length, no. of grains/spike, grain yield (kg/ha) and straw yield (kg/ha) were significantly higher in plants inoculated with seed treatment especially PSB in liquid form. Interaction effect of liquid phosphobacteria with seed treatment was a good combination. However, the maximum grain yield was recorded with application of liquid phosphor bacteria followed by *Azotobacter*. The highest gross return (Rs. 72832/ha) and net return (Rs.64532/ha) was obtained with liquid phospho bacteria seed treatment combination.

Das *et al.* (2019) stated that *Azotobacter*s results in better yield of cereals like corn, wheat, oat, barley, rice, pearl millet and sorghum, of oil seeds like mustard and sunflower, of vegetable crops like tomato, eggplant, carrot, chilies, onion, potato, beans and sugar beet, of fruits like mango and sugar cane, of fiber crops like jute and cotton and of tree like oak.

Jafari, *et al.* (2015) told that the interaction between *Azotobacter* and Bio-phosphate showed significant effects on stem height, number of spikes per square meter, number of grains per spike, and grain yield, highlighting the importance of these fertilizers in enhancing wheat productivity.

Chennappa *et al.* (2022) proved that the findings suggest that utilizing *Azotobacter* species as bio-agents can reduce the dependence on synthetic fertilizers and pesticides, promoting sustainable agricultural practices.

Muhammad Ali *et al.* (2008) stated that a positive correlation was found in *Azotobacter* colonization between root and rhizosphere, but it was negative in case of the population between heterotrophic bacteria and *Azotobacter* in rhizosphere. The highest amount of N was found to be fixed by the isolate M1 and the lowest by the isolate M4 and it was respectively 9.26 and 5.45 mg N/g substrate. In terms of the capacity to fix nitrogen in laboratory condition the five isolates of *Azotobacter* could be arranged as M1> M3 > M5 > M4 > M2.

Hossein *et al.* (2019) stated that plant height, grains number per ear and biological yield were significantly higher in inoculated plants than in non-inoculated plants. And application of *Azotobacter* in present of 50% N recommended had an appropriate performance and could increase grain yield to an acceptable level, so it could be considered as a suitable substitute for chemical nitrogen fertilizer in organic agricultural systems.

Chennappa Gurikar (2022), claimed that, the antimicrobial compounds produced by *Azotobacter* species can serve as a natural defense mechanism against plant diseases caused by phytopathogens, offering a sustainable approach to disease management in agriculture.

Nirbhay Kumar Singh *et al.* (2013) explained that, *Azotobacter* strain (Azo-8) with urea (60 KgN ha^{-1}) and farmyard manure (40 KgN ha^{-1}) resulted in notable increases in shoot and root fresh weight, dry weight, seed test weight, and overall yield compared to the control group. Specifically, there was a more than 23% and 36% increase in shoot fresh weight and dry weight, a 26% and 38% increase in root fresh weight and dry weight, a 39% increase in seed test weight, and a 27% increase in yield over the control group.

Umesh K. Bageshwar, *et al.* (2017) concluded that, environment friendly approach to agriculture by developing an engineered *Azotobacter* strain, *Azotobacter* chroococcum HKD15, which significantly enhances nitrogen fixation efficiency and reduces the need for urea fertilizer in wheat cultivation

Deepika Chaudhary *et al.* (2013) stated that, Inoculation with salinity tolerant *Azotobacter* strains caused significant increase in total nitrogen, biomass and grain yield of wheat. Maximum increase in plant growth parameters were obtained after inoculation with *Azotobacter* strain ST24 at fertilization dose of 120 kg N ha^{-1} and its inoculation resulted in attaining 89.9 cms plant height, 6.1 g seed yield, 12.0 g shoot dry weight and 0.7 % total nitrogen. The survival of *Azotobacter* strain ST24 in the soil was also highest in all the treatments at 30, 60 and 90 days after sowing (DAS). However, the population of

Azotobacter decreased on 90 DAS as compared to counts observed at 60 DAS at all the fertilization treatments.

The effectiveness of bacterial inoculation on wheat seed quality (germination energy and percentage), yield and 1000-seed weight were shown to depend on the amount of applied urea and wheat cultivar. Wheat seed inoculation with A. chroococcum affected positively all parameters in the variants without urea application and the lowest dose of urea. Negative results were recorded in the variants with medium and high doses of urea in combination with Inoculation.

Kiranpreet Kaur (2017) explained that, plant growth parameters like shoot and root length, fresh and dry weight of shoot and root, chlorophyll content were found to be significantly enhanced in inoculation with 100% RDF +*Azotobacter* + W9 over the control. In first trial (2015-16), maximum grain yield was showed by T_{11} (100% RDF +*Azotobacter*+ W9) i.e. 51.88 q/ha as compared to control (T_2 & T_1) was 45.41 & 40.13 (q/ha). Similar trend was observed in second trial (2016-17), where also T_5 (100% RDF+ W9+ *Azotobacter*) showed maximum grain yield (49.5 q/ha) as compared to control (40.3 q/ha). Hence, these actinomycete isolate W9 and *Azotobacter* are potential candidates for enhancing plant growth that can help in the use of eco-friendly bio-fertilizers.

Aisha Sumbul stated that, the *Azotobacter* is widely used in agriculture to increase soil fertility and stimulate plant growth. The presence of *Azotobacter* is prominent in biofertilizers. They are also crucial in the manufacture of alginic acid that is renowned in medicine as an antacid.

Fatema-Tuz-Zohura (2018), explained that, furthermore, experiments with plant extracts, including Neem, Garlic, and Black cumin, have shown promising results in inhibiting the growth of *M. oryzae* and managing wheat blast disease effectively.

Liaquat, Ali *et al.* (2003) expresses that, seed inoculation with *Azotobacter* significantly increased the plant height. Besides nitrogen fixation, *Azotobacter* has been found to synthesize growth promoting substances and antibiotics.

Nagaraja *et al.* (2022), stated that in maize, sorghum, and wheat, *Azotobacter* salinestris strain Azt 31 exhibits notable antifungal effectiveness against *Fusarium* spp. that produce trichothecene.

Nirbhay Kumar Singh, *et al*. (2013) concluded that in dryland wheat farming, using *Azotobacter* bio-inoculant can be a promising substitute for chemical fertilisers, increasing crop yield and maintaining soil health.

Badaruddin *et al.* (1991), *Bipolaria sorokiniana* causes a yield loss in wheat of more than 22%.

Bidari *et al.* (1975) stated that there is a wealth of information on chemical control of various wheat diseases, but little is known about *Bipolaris l*eaf blight.

Deepika Chaudhary (2013), concluded that the population of *Azotobacter* decreased by 90 days after sowing across all fertilization treatments, suggesting the need for further research to optimize the inoculation strategy for long-term benefits**.**

Gajraj *et al.* (2023) explained that the importance of utilizing a combination of organic and inorganic fertilizers, specifically nitrogen and Azotobacter, to enhance wheat crop productivity and sustainability.

Muhammad Khalid, *et al.* (1999) stated that the combined application of *Azotobacter* and L-tryptophan (L-TRP) had a significant positive impact on wheat crop growth, yield, and nitrogen content compared to their separate application.

Ishac *et al.* (1984) concluded that inoculation of wheat seeds with selected *Azotobacter* strains or their filtrates had various effects on the rhizosphere microflora, seed germination, plant height, total bacterial counts, colonization of *Azotobacter*, and clostridia in the rhizosphere.

Nirmala Agrawal *et al.* (2002) explained that the antibiotics streptomycin, tetracycline, trimethoprim, nalidixic acid, and rifampicin caused different degrees of resistance in *Azotobacter* cultures, suggesting that there is variation in intrinsic resistance within the species.

Chennappa *et al.* (2017), stated that *Azotobacter* isolates can be used for sustainable agriculture as biofertilizer and bioinoculants.

Salehuddin, *et al.* (2020) concluded that the pathogenic variability of isolates of *Bipolaris sorokiniana* at various phases of wheat growth, including BARI GOM 26 and Kanchan.

Gorica Cvijanov (2012) stated that the effectiveness of bacterial inoculation with *Azotobacter chroococcum* on wheat seed quality, yield, and 1000-seed weight depended on the amount of urea applied and the wheat cultivar.

Magda *et al.* (2012) stated that increased crop productivity can be achieved by applying biofertilizers such as *Azotobacter vinelandii*, *Streptomyces* sp., or a combination of the two, particularly in soil environments that are salinized.

CHAPTER 3
METHODS AND MATERIALS

The experiment was conducted to assess the effect of plant growth hormone *Azotobacter* to reduce the wheat disease effect. In this chapter the methods followed and materials used in the present research work were stated. Details of this experiment i.e. experimental period, location, soil, weather, and materials that are used, experimental treatment and design, growing of crops, data collection and analysis procedure that followed for the conduction of this experiment has been represented under the following headings and sub-headings:

3.1 Experimental site

This experiment was conducted at BARI (Bangladesh Agricultural Research Institute) Rajbari, Dinajpur.

3.2 Experimental period

The experiment was carried out during the rabi season from December to April 2024. The seeds were sown on 09 December 2023 and harvested on 25 April 2024.

3.3 Collection of seed sample

Bari Gom-33 was used in this experiment. Seed sample was collected from the local market. Until the further studies the seeds were then kept in poly bags and stored in the refrigerator at 4degree centigrade.

3.4 Variety used

Hybrid variety of BARI GOM-33 was used in this experiment.

3.5 Soil type

The experimental field was medium high and the soil was sandy loam in texture. The selected plot was above flood level and sufficient sunshine was available having available irrigation and drainage system during the experimental period.

3.6 Climatic condition

The monthly mean of daily, maximum, minimum and average temperature, relative humidity, monthly total rainfall and sunshine hours received at the experimental area during the period of study was collected from Meteorological Department, BWMRI, Nashipur Dinajpur (APPENDIX).

3.7 Treatment of the experiment:

T_1=100% FRG recommended dose (control)

T_2= FRG recommended dose (40%urea+100%TSP+100%MoP) +Azotopex-AC

T_3=FRG recommended dose (75%urea+100%TSP+100%MoP) + Azotopex-AC

T_4=FRG recommended dose+(60% urea+100%TSP+100%MoP)+Azotopex AC

T_5=Farmer's practice (Urea-650g, TSP-550g, MoP-450g, Zipsum-300g)

Treatments percentage are based on Fertilizer Recommendation Guide (FRG).

3.8 Collection of treatment

Urea, TSP & MoP was arranged from Dinajpur local market. Azotopex-AC was collected from Apex biopesticide and Biofertilizer Company. Tilt 250 EC, Gain 20SL and Nativo 75WG was also collected from local market.

3.9 Land preparation

A well drainage medium high land was used for wheat cultivation. The experimental plot had been properly ploughed and cross ploughed. The intercultural operations were done with spade, harrow, hammer etc. The clods were broken into fine soil particles and surface was levelled until the desire tilth was obtained. The weeds and stubbles were removed and at last the experimental design was followed for final land preparation.

3.10 Application of manure and fertilizers

Manures and fertilizers were applied as BARI recommended doses. Used doses are described below:

Fertilizer	Treatment				
	T_1	T_2	T_3	T_4	T_5
Urea $(NH_2)_2CO$	264	212	141	352	650
TSP $(Ca(H_2PO_4)_2.H_2O$	162	162	162	162	550
MoP(KCl)	243	243	243	243	450
Gypsum $(CaSO_4.2H_2O)$	169	169	169	169	300
Zinc (Zn)	13	13	13	13	30
Magnesium (Mg)	85	85	85	85	0
Boron(B)	18	18	18	18	18

Fungicide Application

Fungicide name	**Dose**
Tilt 250EC	0.5 ml/L
Nativo 75 WG	0.6 ml/L
Gain 20 SL	1 ml/L

3.11 Experimental design

The field layout was done after final land preparation. The experiment was set in a Randomized complete Block design (RCBD).

3.12 Replication

Treatment of the experiment was replicated at 4 times.

3.13 Layout

The total field was divided into 4 blocks, each comprising 8 plots of spacing 50cm×50cm. Seeds were sown in line in the experimental plots. Block to block distance was 1m. The seeds were planted at about 3cm depth in the soil.

3.14 Seed Treatment

Wheat seeds were coated uniformly with Azotopex-AC and dry in the shade of 15-20 min and then sow them as soon as possible. (Precaution-the treated seeds were kept in a cool, dry, and shady place. The seeds were being covered with soil as soon as they were sown).

3.15 Soil application of Azotopex-AC

Azotopex-AC was mixed well with organic matter, kept in the shade overnight and broadcast on soil before the final stage of land preparation.

Product	Active Ingredient	Doses
Azotopex-AC	*Azotobacter*	10ml per liter of water and spray or mix with soil or seeds

3.16 Intercultural operation

3.16.1 Thinning

For obtaining optimum plant population in each germinated plant was thinned after the 15days of sowing.

3.16.2 Irrigation

The experimental plot was irrigated three times, at 15 days at 3 leaves, 2nd at booting stage (55days) and 3rd at heading stage.

3.16.3 Weeding

Weeding was done 3 times. After 25 days of sowing weeding was done. The next was done after 55 DAS and 95 DAS.

3.17 Harvesting and collection of data on yield and yield contributing characters

- Plant height (cm)
- Leaf length (cm)
- Leaf breadth (cm)
- Percent disease area of flag leaf (%)
- Percent disease area of flag-1 leaf (%)
- Total number of grains per spike
- Number of normal sized seed per spike (%)
- Number of undersized seeds per spike (%)
- Number of black pointed seed per spike (%)
- Thousand grain weight (gm)
- Germination percentage of seeds (%)
- Straw weight (gm)

3.18 Procedure of data collection

3.18.1 Plant height (cm)

Randomly selected 5 plants were taken to measure the plant height. Plant height was measure by a meter scale in centimeter at both vegetative and reproductive stage.

3.18.2 Leaf length & Leaf breadth

Those were also measured by a meter scale in centimeter. Five randomly selected plants were considered for data collection.

3.18.3 Percent diseased leaf area and severity

Data on percent leaf area was recorded at different days after sowing by visual observation of symptoms. Percent leaf area was calculated by the following formula:

$$\%\text{ Leaf area diseased} = \frac{\%\text{leaf area infected}}{\text{Total leaf area inspected}} \times 100$$

$$\text{Disease severity (\%)} = \frac{\text{Total infected leaf area}}{\text{Total observation} \times \text{maximum grade}} \times 100$$

3.18.4 Evaluation of leaf blight severity

Scale	Description
0	Leaf free from lesion
1	Few isolated lesions covering not more than 1% leaf area
2	5% leaf area covered
3	10% leaf area covered
4	25% leaf area blighted
5	50% leaf area blighted
6	75% leaf area blighted
7	Severe infection with more than 80% leaf area damaged

3.18.5 Sorting of black pointed seed

100 seeds were separated from each plot for this reason. By hand counting method total numbers of seeds were counted. Seeds were sorted in 4 grades - black pointed, under sized, broken & normal though visual observation.

3.18.6 Harvesting of crops

When plants of experimental plots shown 80%-90%maturity based on straw color, pod filling, pod color, water content per plant etc. Total plants were harvested plot wise and tagged. For data collection 20 plots was harvested.

3.18.7 Threshing

Wheat was dried for 3 days on academic building roof and threshed by manually.

3.18.8 Yield

Yield was measured by weighing total harvested grains per plot. For final data preparation the yield was measured in kg/ plot.

3.18.9 Seed health status evaluation of wheat by blotter method

For the detection of seed borne fungi health status of all seed sample was analyzed. For studying the seed health status, the blotter method was used on the samples four hundred seeds were randomly taken and placed on blotter paper in 90 mm Petri dish. Twenty-five seeds were placed at equal distance on three layered moist blotter paper in each of 90mm glass petridish. At room temperature the Petri dishes were placed on the laboratory table. Those Petri dishes were incubated under 12/12 hours light-darkness cycle. After 7days of incubation, the seeds were seen under a stereo binocular microscope for detection of the growth of fungi. From the seed sample temporary slides were prepared and were observed under a compound microscope for identification of associated fungi in order to be confirmed. The fungal genera and species were identified according to different literature (Barnett and Hunter, 1998; Mathur and Kingsdale, 2003).

3.19 Statistical analysis

Collected data from different parameters were properly complied and arranged in excel sheet. Statistix-10-computer package program was used for appropriate statistical analysis. With LSD (Least Significant difference) value at 0.05% alpha value the treatment means were compared (Gomez and Gomez, 1984).

CHAPTER 4

RESULTS

4.1.1 Effect of treatments on percent diseased area of flag leaf

Percent diseased leaf area was recorded at 75, 85 and 95 days after sowing of seeds and presented at table 1. From the table it was observed that at 75, 85 and 95 days after sowing there were statistically significant differences among the treatments.

At 75 days after sowing, the highest percent diseased area of flag leaf was observed in T_1 (23.05%). Treatment T_2 (15.15%) showed the lowest percent diseased area of flag leaf followed by T_3 (19.72%), T_4 (18.22%) and T_5 (16.55%).

At 85 days after sowing, it was presented that T_1 (27.30%) had the highest percent diseased area of flag leaf comparing with the other treatments. T_2 (18.50%) showed the lowest percent diseased area of flag leaf while T_3 (22.55%), T_4 (21.72%) and T_5 (19.65%) had similar effect as T_2 (18.50%) on wheat.

At 95 days after sowing, T_1 (38.62%) had the highest percent diseased area of flag leaf as like 75 and 85 days after sowing. Here lowest percent diseased area of flag leaf was observed in T_5 (24.65%). Treatment T_3 (30.75%), T_4 (26.92%) and T_2 (27.35%) also had similar effect as the lowest percent diseased area of flag leaf at treatment T_5.

Table 1 Effect of treatments on percent disease leaf area of flag leaf recorded at different dates of data collection

Treatments	Percent diseased leaf area of flag leaf		
	75 DAS	85DAS	95DAS
T_1	23.05a	27.30a	38.62a
T_2	15.15ab	18.50b	27.35b
T_3	19.72ab	22.55b	30.75ab
T_4	18.22b	21.72b	26.92b
T_5	16.55b	19.65b	24.65b
SE±	2.44	2.63	3.69
LSD	5.32	6.65	8.05

*Figures having similar letter (s) in a column do not differ significantly at 5% level of significance.

T_1 =100% FRG recommended dose (control)

T_2 =FRG recommended dose (40%urea+100%TSP+100%MoP) +Azotopex-AC

T_3 = FRG recommended dose (75%urea+100%TSP+100%MoP) +Azotopex AC

T_4 =FRG recommended dose (60% urea+100%TSP+100%MoP) +Azotopex-AC

T_5=Farmer’s practice (Urea-650g, TSP-550g, MoP-450g, Zipsum-300g)

4.1.2 Effect of treatments on percent disease severity of flag leaf

Effect of treatment on percent disease severity of flag leaf at 75, 85 and 95 days after sowing was showed in table 2. From the above table it was found that there was variation among the treatment. But the variation was not statistically significant at 75 days after sowing. At 85 and 95 days after sowing the variation was statistically significant.

At 75 days the highest percent disease severity of flag leaf was observed in treatment T_3 (17.85%) and the lowest percent disease severity of flag leaf was observed in treatment T_2 (14.90%). Treatment T_4 (16.90%) and T_5 (16.82%) had the similar effect as the highest percent disease severity of flag leaf. And T_1 (15.31%) had the similar effect as $T_{2.}$

At 85 days the highest percent disease severity of flag leaf was observed in treatment T_1 (27.30%) and the lowest percent disease severity of flag leaf was observed in treatment T_2 (18.50%). T_3 (22.55%), T_4 (18.62%) and T_5 (19.65%) had the same effect as like as the lowest percent disease severity of flag leaf T_2.

At 95 days highest percent disease severity of flag leaf was found in treatment T_1 (38.62%) and the lowest percent disease severity of flag leaf was observed in treatment T_4 (23.27%) followed by T_2, T_3 and T_5 consisting 27.35%, 30.75%and 24.65%, disease severity, respectively.

Table 2 Effect of treatment on percent disease severity of flag leaf at 75, 85 and 95 days after sowing

Treatments	Percent disease severity of flag leaf		
	75DAS	85DAS	95DAS
T_1	15.31ns	27.30a	38.62a
T_2	14.90	18.50b	27.35b
T_3	17.85	22.55b	30.75ab
T_4	16.90	18.62b	23.27b
T_5	16.82	19.65b	24.65b
SE±	1.97	2.17	3.70
LSD	4.30	4.73	8.06

*At 5% level of probability figures in a column having similar letter (s) do not differ significantly.

T_1 =100% FRG recommended dose (control)

T_2 =FRG recommended dose (40%urea+100%TSP+100%MoP) +Azotopex-AC

T_3 = FRG recommended dose (75%urea+100%TSP+100%MoP) +Azotopex AC

T_4 =FRG recommended dose (60% urea+100%TSP+100%MoP) +Azotopex-AC

T_5=Farmer's practice (Urea-650g, TSP-550g, MoP-450g, Zipsum-300g)

4.1.3 Effect of treatment on percent diseased leaf area of penultimate leaf

In table 3, effect of treatment on percent diseased leaf area of penultimate leaf was expressed. Percent diseased leaf area of penultimate leaf was recorded at 75, 85 and 95 days after sowing. There was variation among the treatment and the variation were statistically significant.

At 75 days after sowing, treatment T_5 (16.92%) recorded the highest percent diseased leaf area of penultimate leaf. The lowest percent diseased leaf area of penultimate leaf was recorded at T_4 (10.52%) following T_1 (11.25%), T_2 (12.27%) and T_3 (12.67%), respectively.

At 85 days after sowing, the highest percent diseased leaf area of penultimate leaf was recorded at treatment T_2 (33.90%). Treatment T_1 (32.35%), T_3 (32.25%) and T_5 (31.32%) had the similar effect as T_2. The lowest percent diseased leaf area of penultimate leaf was observed in T_4 (28.20%).

At 95 days after sowing, the highest percent diseased leaf area of penultimate leaf was recorded at treatment T_1 (63.05%) while T_3 (60.90%) had the similar effect as the highest percent diseased leaf area of penultimate leaf at $T_{1.}$ Percent diseased leaf area of penultimate leaf was shown the lowest effect at T_4 (55.60%), while T_2 (58.05%) and T_5 (59.85%) had the similar effect as the lowest percent diseased leaf area of penultimate leaf.

Table 3 Effect of treatment on percent diseased leaf area of penultimate leaf recorded at different dates of data collection

Treatment	Percent disease leaf area of penultimate leaf		
	75DAS	85DAS	95DAS
T_1	11.25b	32.35ab	63.05a
T_2	12.27b	33.90a	58.05ab
T_3	12.67b	32.25ab	60.90ab
T_4	10.52b	28.20b	55.60b
T_5	16.92a	31.32ab	59.85ab
SE±	1.12	2.25	3.05
LSD	2.46	4.90	6.65

*Figures in a column having similar letter (s) do not differ significantly at 5% level of probability.

T_1 =100% FRG recommended dose (control)

T_2 =FRG recommended dose (40%urea+100%TSP+100%MoP) +Azotopex-AC

T_3 = FRG recommended dose (75%urea+100%TSP+100%MoP) +Azotopex AC

T_4 =FRG recommended dose (60% urea+100%TSP+100%MoP) +Azotopex-AC

T_5=Farmer's practice (Urea-650g, TSP-550g, MoP-450g, Zipsum-300g)

4.1.4 Effect of treatment on percent disease severity of penultimate leaf

Percent disease severity of penultimate leaf was presented in table 4. On the basis of visible typical symptoms, the percent disease severity of penultimate leaf area was noted at 75 DAS, 85DAS and 95DAS.

The above table shown that at 75, 85 and 95 days after sowing there were differences among treatment and percent disease severity of penultimate leaf was statistically significant at 75,85 and 95 days after sowing.

At 75 days after sowing, percent disease severity of penultimate leaf was observed maximum in T_2 having (24.23%). The lowest response was found in T_4 (20.85%). The rest treatment had shown the similar effect as like as T_4 on wheat. T_1 (23.58%), T_3 (22.42%) and T_5 (22.41%) had the similar effect as like as treatment T_4.

In case of 85 DAS of observation percent disease severity of penultimate leaf was found highest in T_5 (control treatment) having (42.77%) which was followed by T_2, and T_3 having (41.31%) and (41.56%), respectively. While T_4 (36.84%) was showed the lowest statistically response followed by T_1 consisting (39.60%).

In 95 days after sowing of observation, the highest percent disease severity of penultimate leaf was noted in T_3 (61.35%). And the lowest was found in T_4 (46.95%) followed by T_1, T_2 and T_5 consisting (55.47%), (57.11%) and (53.42%), respectively.

Table 4 Effect of treatment on percent disease severity of penultimate leaf recorded at different dates of data collection

Treatment	Percent disease severity of penultimate leaf		
	75DAS	85DAS	95DAS
T_1	23.58a	39.60ab	55.47b
T_2	24.23a	41.31ab	57.11ab
T_3	22.42ab	41.56a	61.35a
T_4	20.85b	36.84b	46.95c
T_5	22.41ab	42.77a	53.42b
SE±	1.21	2.03	2.55
LSD	2.67	4.54	5.56

*Figures in a column having similar letter (s) do not differ significantly at 5% level of probability

T_1 =100% FRG recommended dose (control)

T_2 =FRG recommended dose (40%urea+100%TSP+100%MoP) +Azotopex-AC

T_3 = FRGrecommended dose (75%urea+100%TSP+100%MoP) +Azotopex AC

T_4 =FRG recommended dose (60% urea+100%TSP+100%MoP) +Azotopex-AC

T_5=Farmer's practice (Urea-650g, TSP-550g, MoP-450g, Zipsum-300g)

4.1.5 Effect of treatment on plant height (cm) per plot

Effect of different treatment on plant height was observed at different date of sowing. Data was recorded at 35, 55 and 107 days of sowing. Different treatment had shown considerable effect on various dates.

At 35 days of sowing, treatment T_4 (44.72cm) exhibited the most effective performance height. And the lowest height was observed at treatment T_3 (38.62cm) followed by T_1, T_2 and T_5 having (41.70cm), (42.02cm) and (40.27cm), respectively.

In case of 55 days after sowing T_2 recorded the highest height and it was (83.95cm). Treatment T_1 shown the lowest height (79.65cm). The rest treatment shown the similar effectiveness as T_1. Treatment T_3, $T_4$and T_5 consisting (82.25cm), (80.05cm) and (82.25cm) respectively. T_3 and T_5 observed same height at 55 days.

In 107 days of observation T_4 (94.62cm) recorded the highest height. Treatment T_3 was showing the lowest height among the treatment containing (84.55cm) Other treatments T_1 (90.37cm), T_2 (91.17cm) and T_5 (89.02cm) was recorded the similar effectiveness like T_3.

Table 5 Effect of treatment on plant height (cm) per plot at different dates of data collection

Treatments	Plant Height (cm)		
	35 DAS	55 DAS	107 DAS
T_1	41.70ab	79.65b	90.37bc
T_2	42.02ab	83.95a	91.17b
T_3	38.62b	82.25ab	84.55d
T_4	44.72a	80.05ab	94.62a
T_5	40.27b	82.25ab	89.02c
SE±	1.60	1.89	0.89
LSD	3.50	4.12	1.95

*Figures in a column having similar letter (s) do not differ significantly at 5% level of probability.

T_1 =100% FRG recommended dose (control)

T_2 =FRG recommended dose (40%urea+100%TSP+100%MoP) +Azotopex-AC

T_3 = FRG recommended dose (75%urea+100%TSP+100%MoP) +Azotopex AC

T_4 =FRG recommended dose (60% urea+100%TSP+100%MoP) +Azotopex-AC

T_5=Farmer's practice (Urea-650g, TSP-550g, MoP-450g, Zipsum-300g)

4.1.6. Effect of treatment on leaf length and leaf breadth (cm)

On leaf length and leaf breadth different treatments had various effects. Table 6 shown the variation among the treatments against leaf length and leaf breadth. The differences among treatments were statistically significant. The maximum leaf length was observed in treatment T_4 containing (28.75cm). Treatment T_2 was had similar effect having (27.97cm). Here T_3 (26.20cm) expressed the minimum leaf length. The other treatments were followed by treatment T_3. Here T_1, T_2 and T_5 obtained (26.87cm), (27.975cm) and (26.97cm) leaf length, respectively.

Leaf breadth also showed discrimination among the treatments. All the treatments were shown variation in leaf breadth and the differences were statistically significant. T_1 (2.04cm) reported the maximum leaf breadth followed by T_2 (1.98cm). The minimum leaf breadth was recorded at treatment T_5 (1.63cm). As like T_5 the treatment T_3 and T_4 had similar effect. T_3 and T_4 shown same effect as the minimum leaf breadth T_5 having (1.89cm) and (1.79cm), respectively.

Table 6 Effect of treatment on leaf length and leaf breadth(cm) at 65DAS of data collection

Treatment	Leaf Length (cm)	Leaf Breadth(cm)
T_1	26.87ab	2.04a
T_2	27.97ab	1.98a
T_3	26.20b	1.89ab
T_4	28.75a	1.79ab
T_5	26.97ab	1.63b
SE±	1.12	0.12
LSD	2.44	0.26

*Figures in a column having similar letter (s) do not differ significantly at 5% level of probability.

T_1 =100% FRG recommended dose (control)

T_2 =FRG recommended dose (40%urea+100%TSP+100%MoP) +Azotopex-AC

T_3 = FRG recommended dose (75%urea+100%TSP+100%MoP) +Azotopex AC

T_4 =FRG recommended dose (60% urea+100%TSP+100%MoP) +Azotopex-AC

T_5=Farmer's practice (Urea-650g, TSP-550g, MoP-450g, Zipsum-300g)

4.1.7. Effect of treatment on panicle length(cm).

Effectiveness of the treatments was recorded on 90 DAS and 110 DAS. The panicle length was varied against the treatments and statistically significant.

At 90 days after sowing the highest panicle length was observed at treatment T_4 (11.82cm). The lowest was in treatment T_3 (9.6cm). The other treatments had similar effect as T_3. Treatment T_1, T_2 and T_5 having (10.37cm), (10.25cm) and (10.92cm), respectively.

In 110 days after sowing, highest panicle length was recorded on treatment T_4 having (12.95cm) and treatment T_3 had the lowest effect having (9.5cm). The rest treatments shown effectiveness as like treatment T_3. Treatment T_1, T_2 and T_5 contained (10.53cm), (11.15cm) and (10.92cm), respectively.

Table 7: Effect of treatment on spike length(cm) at 90 DAS and 110 DAS of data collection

Treatments	Spike length (cm)	
	90DAS	110 DAS
T_1	10.37ab	10.53bc
T_2	10.25b	11.15b
T_3	9.6b	9.5c
T_4	11.82a	12.95a
T_5	10.12b	10.92b
SE±	0.72	0.50
LSD	1.57	1.11

*Figures having similar letter (s) do not differ significantly in a column at 5% level of probability.

T_1 =100% FRG recommended dose (control)

T_2 =FRG recommended dose (40%urea+100%TSP+100%MoP) +Azotopex-AC

T_3 = FRG recommended dose (75%urea+100%TSP+100%MoP) +Azotopex AC

T_4 =FRG recommended dose (60% urea+100%TSP+100%MoP) +Azotopex-AC

T_5=Farmer's practice (Urea-650g, TSP-550g, MoP-450g, Zipsum-300g)

4.1.8. Effect of different treatment on total number of grains no. per spike

Table number 08 expressed the total number of grains per spike. There was variation among the treatments and they are statistically significant. The highest and lowest number of grains were found in treatment T_4 and T_3 carrying (51.97) and (44.15), respectively. T_1 contained (44.27), and T_2 and T_5 contained (46.70) and (48.45), respectively.

Table 8: Effect of different treatment on total number of grains no. per spike

Treatment	Grain no. per spike
T_1	44.27b
T_2	46.70ab
T_3	44.15b
T_4	51.97a
T_5	48.45ab
SE±	2.87
LSD	6.27

The value having same letter (s) within the column does not differ significantly at 5% level of significant.

T_1 =100% FRG recommended dose (control)

T_2 =FRG recommended dose (40%urea+100%TSP+100%MoP) +Azotopex-AC

T_3 = FRG recommended dose (75%urea+100%TSP+100%MoP) +Azotopex AC

T_4 =FRG recommended dose (60% urea+100%TSP+100%MoP) +Azotopex-AC

T_5=Farmer's practice (Urea-650g, TSP-550g, MoP-450g, Zipsum-300g)

4.1.9. Effect of different treatment on several yield contributing character of wheat

After harvesting seeds were graded into four grades. Seeds were divided into normal seed, undersized seed, broken seed and black pointed seed.

4.1.9.1 Normal seed

There was variation among the normal seeds but they were not statistically significant. Treatment T_3 (77.00%) recorded the highest percentage of normal seed. Treatment T_1 and T_4 had the similar effect as treatment T_3 while T_1 and T_3 contained (70.50%) and (71.50%). The lowest normal seed percentage was carried by treatment T_2 containing (66.75%). T_5 (68.00%) shows the result as like as treatment T_2 which contain the lowest normal seed percentage.

4.1.9.2. Undersized seed

There was shown differences among the treatments of undersized seeds. And the variations were also statistically significant. Maximum range was observed at treatment T_2 containing (23.75%). Treatment T_1 which had contained (21.25 %) given the similar effectiveness as T_2. Minimum range was observed at treatment T_3 (11.50%) followed by T_4 and T_5 containing (16.50%) and (17.50%), respectively.

4.1.9.3 Broken seed

There were differences among the treatments on broken seed but they were not statistically significant. Treatment T_5 shows the highest broken seed while T_1 shown the lowest one. T_1, T_2, T_3, T_4 and T_5 contains (4.50%), (6.50%), (7.00%), (8.75%) and (10.00%), respectively. T_1, T_2, T_3 expresses similar effect while T_4 and T_5 shows similar effect.

4.1.9.4. Black pointed seed

Black pointed seeds were not shown statistical differences among treatments. The highest was observed in both treatment T_4 and T_5 containing (4.50%). And the lowest was observed at T_2 which contained (3.00%). Treatment T_1 (3.75%) and T_4 (3.25%) also shown the similar effect as treatment.

Table 9: Effect of different treatment on several yields contributing character of wheat

Treatments	Percent grading of seed after harvest			
	Normal seed	Undersized seed	Broken seed	Black pointed seed
T_1	70.50ns	21.25ab	4.50ns	3.75ns
T_2	66.75	23.75a	6.50	3.00
T_3	77.00	11.50b	7.00	4.50
T_4	71.50	16.50ab	8.75	3.25
T_5	68.00	17.50ab	10.00	4.50
SE±	6.65	4.70	2.88	1.50
LSD	14.49	10.25	6.29	3.27

The value having same letter (s) within the column does not differ significantly at 5% level of significant.

T_1=100% FRG recommended dose (control)

T_2=FRG recommended dose (40%urea+100%TSP+100%MoP) +Azotopex-AC

T_3=FRG recommended dose (75%urea+100%TSP+100%MoP) +Azotopex-AC

T_4=FRG recommended dose (60% urea+100%TSP+100%MoP) +Azotopex-AC

T_5= Farmer's practice (Urea-650g, TSP-550g, MoP-450g, Zipsum-300g)

4.1.10: Effect of different treatment on total yield (kg) per plot

In table 10 effect of different treatment on total yield (kg) per plot was expressed. Here statistical variation was shown among the treatments. The highest yield was observed in T_4 (13.25kg). And lowest yield was found in T_3 (11.77kg). Treatment T_1, T_2 and T_5 contained 12.38kg, 11.91kgand 11.77kg, respectively. Treatment T_1, T_2 and T_5 had similar effect as like as the lowest yield T_3.

Table 10: Effect of different treatment on total yield (kg) per plot

Treatment	Total yield (kg) per plot
T_1	12.38ab
T_2	11.91ab
T_3	11.74b
T_4	13.25a
T_5	11.77b
SE±	0.65
LSD	1.41

*Figures in a column having similar letter (s) do not differ significantly at 5% level of probability.

T_1=100% FRG recommended dose (control)

T_2=FRG recommended dose (40%urea+100%TSP+100%MoP) +Azotopex-AC

T_3=FRG recommended dose (75%urea+100%TSP+100%MoP) +Azotopex-AC

T_4=FRG recommended dose (60% urea+100%TSP+100%MoP) +Azotopex-AC

T_5= Farmer's practice (Urea-650g, TSP-550g, MoP-450g, Zipsum-300g)

4.1.11: Effect of different treatment on thousand grain weight (gm)

Effect of different treatment on thousand grain weight (gm) was expressed in table-11. There was variation among the treatment but these were not statistically significant. The highest value was observed in T_4 (54.01g). While the lowest was found in T_2 (50.30g). Treatment T_1 (52.02g) expresses the similar effect as T_4 and Treatment T_3 (51.62g) and T_5 (50.95g) had shown the similar effect as T_2.

Table 11 Effect of different treatment on thousand grain weight (gm)

Treatments	Thousand grain weight (gm)
T_1	52.02ns
T_2	50.30
T_3	51.62
T_4	54.01
T_5	50.95
SE±	2.35
LSD	5.12

*Figures in a column having similar letter (s) do not differ significantly at 5% level of probability.

T_1=100% FRG recommended dose (control)

T_2=FRG recommended dose (40%urea+100%TSP+100%MoP) +Azotopex-AC

T_3=FRG recommended dose (75%urea+100%TSP+100%MoP) +Azotopex-AC

T_4=FRG recommended dose (60% urea+100%TSP+100%MoP) +Azotopex-AC

T_5= Farmer's practice (Urea-650g, TSP-550g, MoP-450g, Zipsum-300g)

4.1.12. Effect of different treatment on spikelet per panicle

Effect on spikelet was recorded on table no 12. In this table the maximum value was observed in treatment T_4 which contained 18.85. The minimum value was observed in treatment T_1 which contained 17.75. The rest treatment T_2, T_3 and T_5 contained 17.80, 18.70 and 18.55, respectively. Here all the treatments were contained different value but variations were not statistically significant.

Table 12 Effect of different treatment on spikelet per panicle

Treatment	No. Spikelet per panicle
T_1	17.75ns
T_2	17.80
T_3	18.70
T_4	18.85
T_5	18.55
SE±	1.32
LSD	2.88

*Figures in a column having similar letter (s) do not differ significantly at 5% level of probability.

T_1=100% FRG recommended dose (control)

T_2=FRG recommended dose (40%urea+100%TSP+100%MoP) +Azotopex-AC

T_3=FRG recommended dose (75%urea+100%TSP+100%MoP) +Azotopex-AC

T_4=FRG recommended dose (60% urea+100%TSP+100%MoP) +Azotopex-AC

T_5= Farmer's practice (Urea-650g, TSP-550g, MoP-450g, Zipsum-300g)

4.1.13 Effect on yield contributing character of wheat

Straw weight of wheat is a yield contributing character. In the table no 13 average straw weight was shown. There was deference among the treatments and the variation was statistically significant. The highest straw weight was seen in the treatment T_4 which contained (26.91gm) and T_3 (25.17gm) had similar effect as T_4. The lowest straw weight expressed at treatment T_1 (22.56gm). Treatment T_2 (22.86gm) and T_5 (22.99gm) shown the similar effect as treatment T_1.

Table 13: Effect on yield contributing character of wheat

Treatment	Straw weight (g)
T_1	22.56b
T_2	22.86b
T_3	25.17ab
T_4	26.91a
T_5	22.99ab
SE±	1.82
LSD	3.98

*Figures in a column having similar letter (s) do not differ significantly at 5% level of probability.

T_1=100% FRG recommended dose (control)

T_2=FRG recommended dose (40%urea+100%TSP+100%MoP) +Azotopex-AC

T_3=FRG recommended dose (75%urea+100%TSP+100%MoP) +Azotopex-AC

T_4=FRG recommended dose (60% urea+100%TSP+100%MoP) +Azotopex-AC

T_5= Farmer's practice (Urea-650g, TSP-550g, MoP-450g, Zipsum-300g)

4.1.14 Effect on germination percentage of wheat

Table 14 recorded the germination percentage of wheat seed after harvested. There was variation among the treatments which were statistically significant.

Germinated seed was maximum on treatment T_4 contained (90.50%) treatment T_5 had the similar effect as maximum valueT4.Minumum percent germination was observed on treatment T_3 which obtained (79.0%). Treatment $T_1$and T_2 expressed the similar effect as the minimum vale and they contained (85.0%) and (81.75%), respectively.

Percent of dead seedling was maximum on treatment T_2 (18.25%) followed by T_1 (15.0%) and T_3 (16.0%). Minimum percent dead seed was recorded on treatment T_4 (9.50%). Treatment T_5 (9.75%) had similar effectiveness as T_4.

Table 14: Effect on germination percentage of wheat

Treatment	Percentage of seed germination	Percentage of dead seedling
T_1	85.0ab	15.0ns
T_2	81.75ab	18.25
T_3	79.0b	16.0
T_4	90.50a	9.50
T_5	90.25a	9.75
SE±	4.98	4.32
LSD	10.87	9.42

*Figures in a column having similar letter (s) do not differ significantly at 5% level of probability.

T_1=100% FRG recommended dose (control)

T_2=FRG recommended dose (40%urea+100%TSP+100%MoP) +Azotopex-AC

T_3=FRG recommended dose (75%urea+100%TSP+100%MoP) +Azotopex-AC

T_4=FRG recommended dose (60% urea+100%TSP+100%MoP) +Azotopex-AC

T_5= Farmer's practice (Urea-650g, TSP-550g, MoP-450g, Zipsum-300g)

4.1.15 Effect on normal and abnormal seedling of wheat against different treatments

Table no 15 was described the percent seedling of normal and abnormal seedlings.

Differences were found on the normal seedlings among the treatments and the variations were statistically significant. The highest vale was recorded on T_4 (86.75%) and lowest was recorded on T_2 (77.0%). Treatment T_5 (83.50%) shown the similar effect as T_4 (86.75%) and T_1 (77.75%), and T_3 (78.25%) shown the similar effect as T_2 (77.0%).

There was variation among the treatments and variation was statistically significant. Percent abnormal seed germination was highest on treatment T_5 (6.75%). And lowest was recorded on T_4 (3.75%). Treatment T_1 (5.77%), T_2 (4.75%) and T_3 (5.75%) was as similar as T_4.

Table 15: Effect on normal and abnormal seedling of wheat against different treatments

Treatment	Percent normal seedling	Percent abnormal seedling
T_1	77.75 ns	5.775ab
T_2	77.0a	4.75ab
T_3	78.25	5.75ab
T_4	86.75	3.75b
T_5	83.50	6.75a
SE±	4.58	0.96
LSD	9.99	2.10

*Figures in a column having similar letter (s) do not differ significantly at 5% level of probability.

T_1=100% FRG recommended dose (control)

T_2=FRG recommended dose (40%urea+100%TSP+100%MoP) +Azotopex-AC

T_3=FRG recommended dose (75%urea+100%TSP+100%MoP) +Azotopex-AC

T_4=FRG recommended dose (60% urea+100%TSP+100%MoP) +Azotopex-AC

T_5= Farmer's practice (Urea-650g, TSP-550g, MoP-450g, Zipsum-300g)

4.1.16 Prevalence of seed borne fungi in wheat variety BARI GOM-33

There was *Bipolaris* sp. *Alternaria* sp. *Curvularia* sp. *Fusarium* sp. *Aspergillus* sp. found on the seeds.

***Bipolaris* sp**

Differences among treatments were significant treatment T_3 (17.60%) contained the highest value and T_4 (13.30%) was recorded the lowest value. The other treatments T_1, T_2 and T_5 contained (14.60%), (15.31%) and (14.97%), respectively.

***Alternaria* sp**

Variation among the treatments was statistically significant. The highest value was recorded on treatment T_3 (9.75%) and the lowest was recorded on T_4 (7.22%). Treatment T_1 (9.45%), and T_5 (9.17%) had shown similar effect as T_3. Treatment T_2 (8.31%) had shown similar effectiveness as T_4.

***Curvularia* sp**

Variation among the treatments was statistically significant. The highest value was recorded on treatment T_3 (7.90%) and the lowest was recorded on T_4 (4.17%). Treatment T_1 (5.6%), T_2 (6.22%), and T_5 (5.7%) had shown similar effectiveness as T_4 (4.17%).

***Fusarium* sp**

Different treatments showed variation on *Fusarium* sp. The recorded value was statistically significant. The highest value was recorded on treatment T_3 (5.57%)

and the lowest was recorded on T_4 (3.35%). Treatment T_1 (4.57%), T_2 (4.52%), and T_5 (4.42%) had shown similar effectiveness as T_4 (3.35%).

***Aspergillus* sp**

Different treatments showed variation on *Aspergillus* sp. which were statistically significant. The highest value was recorded on treatment T_3 (10.47%) and the lowest was recorded on T_4 (6.22%). Treatment T_1 (7.65%), T_2 (7.80%), and T_5 (6.97%) had shown similar effectiveness as T_4 (6.22%).

Table 16 Prevalence of seed borne fungi in wheat variety BARI GOM-33

Treatment	*Bipolaris* sp. (%)	*Alternaria* sp. (%)	*Curvularia* sp. (%)	*Fusarium* sp. (%)	*Aspergillus* sp. (%)
T_1	14.60bc	9.45ab	5.6b	4.57ab	7.65b
T_2	15.31b	8.31bc	6.22b	4.52b	7.80b
T_3	17.60a	9.75a	7.90a	5.57a	10.47a
T_4	13.30c	7.22c	4.17c	3.35c	6.22c
T_5	14.97bc	9.17ab	5.7b	4.42b	6.97bc
SE±	0.86	0.59	0.37	0.46	0.56
LSD	1.88	1.29	0.81	1.01	1.22

*Figures in a column having similar letter (s) do not differ significantly at 5% level of probability.

T_1=100% FRG recommended dose (control)

T_2=FRG recommended dose (40%urea+100%TSP+100%MoP) +Azotopex-AC

T_3=FRG recommended dose (75%urea+100%TSP+100%MoP) +Azotopex-AC

T_4=FRG recommended dose (60% urea+100%TSP+100%MoP) +Azotopex-AC

T_5= Farmer's practice(Urea-650g, TSP-550g, MoP-450g, Zipsum-300g)

Regression coefficient between percent disease leaf area of flag leaf and plant height The linear regression analysis indicated a negative relationship between the plant height and percent disease leaf area of flag leaf, as estimated by the regression equation Y = -0.1095x + 93.194 (R 2 = 0.0268). The fitted line plot graphically displayed the regression result with the equation between the dependent and independent variables of percent disease leaf area. The equation specified that plant height diminishes at a rate of 93.194 with an increase of one unit of disease leaf area. The R 2 value of 0.0268 indicated that 2.68% of the highest plant height could be described by the respective function (Figure 1).

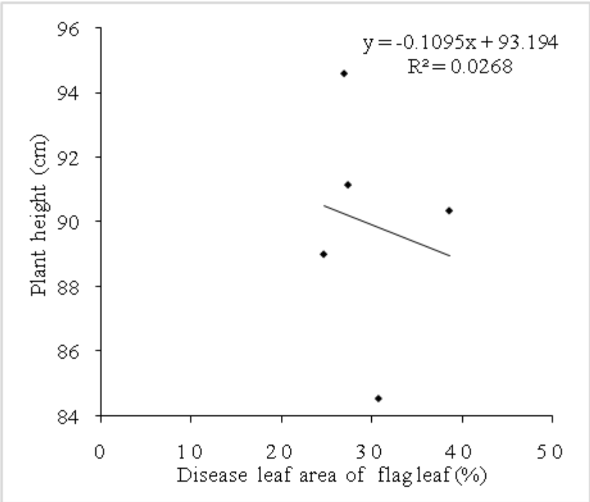

Figure 1. Regression coefficient between percent disease leaf area of flag leaf and plant height

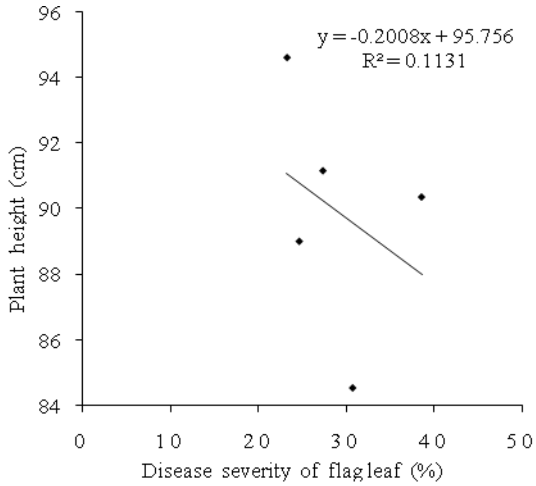

Figure 2. Regression coefficient between percent disease severity of the flag leaf and plant height

4.1.17 Regression coefficient between percent disease severity of the flag leaf and plant height

The linear regression analysis revealed a negative relationship between the number of plants and the percentage of disease severity of the flag leaf. The relationship of the number of plant heights to the intensity of the percent disease severity was derived from the regression equation Y = -0.2008x + 95.756 (R^2 = 0.1131). The fitted line plot presents the regression results with the equation between the dependent variable of the number of plant heights and the independent variable of percent disease severity. The equation indicated that the number of plants decreased at a rate of 95.756, with a rise of one unit of disease severity. The R^2 value of 0.1131 pointed out that 11.31% of the number of plant heights could be clarified through the respective function (Figure 2).

4.1.18 Regression coefficient between percent disease leaf area of the penultimate leaf and plant height

The linear regression analysis revealed a negative relationship between plant height and the percent disease leaf area of the penultimate leaf. The responsiveness of plant height to the intensity of the percent disease leaf area was measured by the regression equation Y = -0.8243x+138.9865 (R^2 = 0.4064). The fitted line plot graphically represents the regression results with the equation between the dependent variable of plant height and the independent variable of percent disease leaf area of the penultimate leaf. The equation showed that the plant height decreased at a rate of 138.99 with an increase of one unit of disease leaf area. The R^2 value of 0.4064 indicated that 40.64% of the plant height could be explained by the respective function (Figure 3).

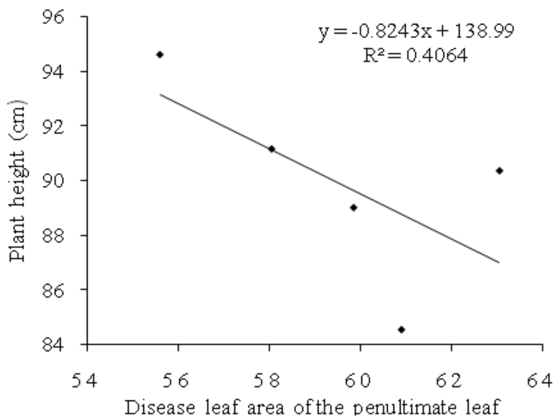

Figure 3.Regression coefficient between percent disease leaf area of the penultimate leaf and plant height

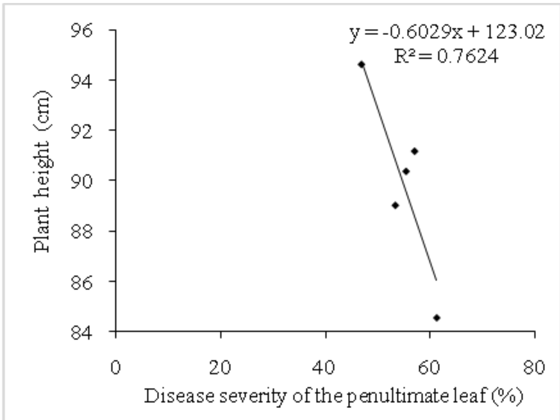

Figure 4. Regression coefficient between percent disease severity of the penultimate leaf and plant height

CHAPTER 5
DISCUSSION

In the previous chapter, the result of the research work was stated. This experiment was set in a randomized complete block design (RCBD) with four replications and carried out during the rabi season from November to March 2024. In this chapter, probable causes of the findings are discussed in the aspects of this research work.

Azotobacter is a nitrogen fixer that is free-living and capable of synthesizing and secreting substantial quantities of biologically active substances, such as biotin, auxins, gibberellins, nicotinic acid, and pentothenic acid. These substances are essential for plant root growth. *Azotobacter* seed inoculation also significantly improved growth parameters (Nazmun *et al.,* 2009; Khan and Kounsar, 2000). Romero-Perdomo *et al.* (2017) found that using a mixed culture of *Azotobacter* starains could lower the need for N fertilizers by up to 50%. With increased N levels, the efficiency of *Azotobacter* is found to be decreasing (Ojaghloo *et al.,* 2007). The combination of N, P, and K fertilization, along with *Azotobacter* application, may significantly improve wheat productivity, suggesting the potential for more effective farming methods to increase crop yields effectively.

The T_2 [(40% urea + 100% TSP + 100% MoP) + AZOTOPEX AC] treatment exhibited the most effective performance, with a diseased area of the flag leaf of 15.15% at 75 DAS and 18.50% at 85 DAS. However, the T_5 treatment outperformed the other treatments, with a diseased area of 24.65% on the flag leaf at 95 DAS. At 75 and 85 DAS, T_2 treatment exhibited the lowest disease severity percentage in the flag leaf. However, at 95 DAS, Treatment T_4 [(60%urea+100%TSP+100%MoP) + AZOTOPEX-AC] exhibited the lowest disease severity percentage in the flag leaf. The lowest percent disease severity of penultimate leaf area at 75, 85, and 95 DAS was reported at T_4, with 20.85%, 36.84%, and 46.95%, respectively. Seed treatment and soil application with *Azotobacter* bio-fertilizer resulted in the lowest (42.60%) disease severity (Biswas *et al.*, 2015).

T_4 recorded the highest plant height, at 35 and 107 DAS. At 55 DAS, T2 showed the highest value of plant height (83.95cm). Mahato and Kafle (2018) found partially comparable funding for the effect of *Azotobacter* inoculation on plant height, panicle length, panicle weight, and grains per plant. Inoculation of seed with *Azotobacter* resulted higher plant height at time of harvest, yield attributing characters and yield of pearl millet (Patel *et al.,* 2014). At 65 DAS, treatment T_4 had the maximum leaf length, measuring 28.75 cm. Leaf breadth was highest at T_1 (control), with a value of 2.04 cm.

The highest spike length was observed at T_4, which contained 11.82 cm at 90 DAS and 12.95 cm at 110 DAS. T_3 exhibits the lowest undersized seed (11.50) and the highest normal seed (77.00). The lowest value of broken seed was observed in T_1 (4.50). The black-pointed seed with the lowest value was obtained by T_2. T_4 exhibits the highest yield (13.25kg), thousand grain weight (54.01gm), and numbers of spikelet (18.85), highest straw weight (26.91gm), germination percentage (90.50), normal seedling (86.75%), and percent abnormal seedling (3.75%). In the case of plant height, tillers plant^{-1}, spikes plant^{-1}, spike length, grain spike^{-1} similar results were observed by Me Carty *et al.* (2017).

Wani *et al.* (2016) showed in their study that plant responses included increased seed germination rates, root development, faster nutrient uptake, root and shoot biomass, and leaf number and area. Applying livestock manure and *Azotobacter* boosted biological yield through an increase in plant height, which caused an improvement in grain yield without any significant changes in harvest index or other yield components, but the use of chemical nitrogen caused an increase in plant height, spikelet spike^{-1}, grain spike^{-1}, 1000 grain weight, harvest index, biological yield, and grain yield (Esmailpour *et al.*, 2013).

At T_4, the percentage of dead seedlings flashed the lowest (9.50%). The potential of *Azotobacter* to increase yield and substitute fertilizers made from chemicals in the cultivation of food crops (Hindersah *et al.*, 2020). *Azotobacter* inoculation significantly increased grain yield, ranging from 2.83 to 6.62 t ha^{-1}, and in addition, the highest grain production (6.42 t ha^{-1}) was achieved with *Azotobacter* inoculation, the recommended synthetic fertilizer dose, and 10 t FYM treatments (Baral and Adhikari, 2013).

T_4 exposed a smaller amount of the seed-associated fungi, namely *Bipolaris* sp. (13.30%), *Alternaria* sp. (7.22%), *Curvularia* sp. (4.17%), *Fuzarium* sp. (3.35%), and *Aspergillus* sp. (6.22%). *Azotobacter* is claimed to create an antibiotic with a structure comparable to anisomycin, a well-known fungicidal antibiotic. *Alternaria, Fusarium, Rhizoctonia, Macrophomina, Curvularia, Helminthosporium*, and *Aspergillus* are some of the pathogens that have been treated using *Azotobacter* as a bioinoculant (Jnawali*et al.,* 2015). Using *Trichoderma* and biofertilizers (*Azotobacter* and PSB) in addition to the recommended fertilizer dosages boosted plant growth and yield, resulting in fewer cases of *Alternaria* blight and white rust diseases (Pathak and Godika, 2010).

CHAPTER 6

SUMMURY AND CONCLUSION

Wheat (*Triticum aestivum L.*) is the most significant cereal crop after rice in Bangladesh and a major staple food in the countries in the South Asian region. Wheat grains contain a large number of calories, protein and highly nutritionally rich food. However, the quality of wheat is very low in compare to other wheat growing countries because of diseases and lack of quality seed.

Leaf blight disease caused by *Bipolaris sorokiana* is one of the serious issues for wheat cultivation. And has significant influence on yield and yield contributing characters. Proper management technique should be established to combat with leaf blight of wheat.

The combined use of urea, TSP, and MoP fertilizers, along with *Azotobacter* application, may significantly improve wheat germination, growth, yield, productivity, and the development of mechanisms against several diseases. This study found that the T_4 [(60%urea+100%TSP+100% MoP) + Azotopex-AC] treatment had a substantial impact on wheat growth, yield, and yield characteristics, and it effectively controlled blight disease. The T_2 [(40% urea+100% TSP+100% MoP) + *Azotopex* AC] treatment produced better results in terms of the lowest black-pointed seed, diseased area of the flag leaf at 75 and 85 DAS, and maximum plant height at 85 DAS.

REFERENCES

AA El-Banna, A Abdel ghany, Ehab A Salama, Hayssam M Ali, Manzer H Siddiqui, NHayatu, Lidia Sas Paszt, Sobhi F Lamlom 08 Jul 2022 - Sustainability- Vol. 14, Iss: 14, pp 8394-8394

Ahmed F, Khan M, and Islam R. 2007. Assessment of yield loss of wheat. Annual research report 2006-2007, BARI, BARS, Jessore. Pp.57.

Akond MA, Mubassara S and Rahman M. (2008, October 10). [Title of the Article]. Bangladesh Journal of Microbiology, 24(2), 151-153.

Alam KB, Sheed MA, Ahmed AU and Malaker PA. 1994. Bipolaris leaf blight of wheat in Bangladesh. CIMMYT, EI Batan, Mexico. Pp. 334-342.

Alamgir M. Famine in South Asia: political economy of mass starvation. Vol. XVIII. Cambridge, MA: Oelgeschlager, Gunn & Hain; 1980. 420 pp.

Anonymous 2014, 'Food and Agriculture Organization of the United Nations, Statistics Division', HTTP://faostat3.fao.org/home/E (accessed 26 January 2016).

Bageshwar UK, Srivastava M, Pardha-Saradhi P, PaulS, Gothandapani S, Jaat RS and Das HK 2017. An environmentally friendly engineered *Azotobacter* strain that replaces a substantial amount of urea fertilizer while sustaining the same wheat yield. Applied and environmental microbiology, 83(15), e00590-17.

Banglapedia 2006. BANGLAPEDIA—national encyclopedia of Bangladesh.

Baral BR and Adhikari P 2010. Effect of *Azotobacter* on growth and yield of maize. *SAARC Journal of Agriculture*, 11(2): 141-147.

BARI (Bangladesh Agricultural Research Institute)2010. Wheat production in Bangladesh: a success story.

http://www.bari.gov.bd/index.php?option=com_simplestforum&view=postlist&topic=true&forumId=1&parentId=288 (4 November 2012).

Becher R and Wirsel SG 2012, 'Fungal cytochrome P450 sterol 14α-demethylase (CYP51) and azole resistance in plant and human pathogens', Applie

Bhandari D, Bhatta MR, Duveiller E and Shrestha SM2003. National Wheat Research Program, arc, Bhairahawa, Nepal. Proceedings of Fourth international Wheat Tan Spot and Spot and Bloch Workshop, Bemidji, Minnesota, USA,21-24july,2002-2003; pp.34-41.

Biswas SK, Shankar, U, Kumar S, Kumar A, Kumar V Lal K 2015. Impact of bio-fertilizers for the management of spot blotch disease and growth and yield contributing parameters of wheat. *Journal of Pure and Applied Microbiology*, 9(4), 3025-3031.

Bockus WW, Bowden RL, Hunger RM, Morrill WL, Murray TD, Smiley RW. 2010.Compendium of wheat diseases and pests, 3rd ed. APS Press, St. Paul, Minnesota, USA

Brien D. 2011. World wheat market supply-demand trends.

Cai Y, Guan K, Lobell D, Potgieter AB, Wang S, Peng J and Peng B 2019. Integrating satellite and climate data to predict wheat yield in Australia using machine learning approaches. *Agricultural and forest meteorology*, *274*, 144-159.

Das HK 2019. *Azotobacter*s as biofertilizer. Advances in applied microbiology, 108, 1-43.

Dean R, Van Kan, JAL Pretorius ZA, Hammond-Kosack KE, Di Pietro, A Spanu PD, Rudd JJ, Dickman M, Kahmann R, Ellis J and Foster GD

2012 'The top 10 fungal pathogensin molecular plant pathology', Molecular Plant Pathology, 13, 414–30.

Effects of *Azotobacter* and Nitrogen Chemical Fertilizer on Yield and Yield Components of Wheat (*Triticum aestivum* L.)

El-zawawy HAH, Abd El-aziz, EAE, and El-Ghomary AE 2023, June 7. Title of the article. Journal of Agricultural Chemistry and Bi..., 0(0), 65-72.

Esmailpour A, Hassanzadehdelouei M, and Madani A. 2013. Impact of livestock manure, nitrogen and biofertilizer (*Azotobacter*) on yield and yield components wheat (*Triticum aestivum* L.). *Cercetari Agronomice in Moldova—Agronomic Research in Moldova*, 46 (2), 5–15.

Franch B 2015. Improving the timeliness of winter wheat production forecast in the United States of America, Ukraine and China using MODIS data and NCAR Growing Degree Day information. Remote Sensing of Environment 161, p:131-148.

Gurikar C, Sreenivasa, MY,Gowda NN, and Lokesh AC. 2022. *Azotobacter*-A potential symbiotic *rhizosphere* engineer. In *Rhizosphere* Engineering (pp. 97-112). Academic Press.

Hindersah R, Kamaluddin NN, Samanta S Banerjee S, and Sarkar S 2020. Role and perspective of *Azotobacter* in crops production. *SAINS TANAH-Journal of Soil Science and Agroclimatology*, 17(2), 170-179.

Hossain I and Azad AK.1992. *Bipolaris sorokiniana,* its reaction and effect on yield of wheat. Wheat Program of Agriculture.5(2):63-69.

Hugo G. Famine as a geographical phenomenon. Boston Reidel 2006. pp. 7–31. 1984.

Index Mundi 2012b. *Bangladesh wheat production by year: market year, production (1000MT) and growth rate (%)*4 November 2012.

Islam MA, Aminuzzaman FM, Islam M, and Zamal MS, 2006. Seed treatment with plant extract and vitavax-200 in controlling leaf spot (*Bipolaris sorokiana*) with increasing grain yield of wheat. Int. J. of Sustain. Agril.Tech.2(8):15-20.

Jafari GA, Laghari KP, Keshavarz KK (2015). International Journal of Biosciences (*Shamokal Publications*)-Vol. 6, Iss: 2, pp 380-388

James D and Mauseth 2018. Botany. An introduction to plant biology. P.223

Jnawali A D, Ojha RB, and Marahatta S (2015). Role of *Azotobacter* in soil fertility and sustainability-a review. Adv. Plants Agric. Res, 2(6), 1-5.

Kashem MA, Hasan AI, & Hossain, MA. (2018). Effects of plant extracts on controlling wheat blast disease caused by Magnaporthe oryzae Pathotype triticum in Bangladesh. Fundamental and Applied Agriculture, 3(2), 422-433.

Khan MR. and Kounsar K. 2000. Effect of seed treatment with certain bacteria and fungi on the growth of Mungbean and reproduction of Meloidogyne incognita. *Nematologia-Mediterranea*, 28(2): 221-226.

Kumar A, Maurya BR, and Raghuwanshi R. (2014). Isolation and characterization of PGPR and their effect on growth, yield and nutrient content in wheat (*Triticum aestivum L.).*Biocatal. Agric. Biotechnol. 3, 121–128.

Lopez J A, Rojas K and Swart J (2015), 'The economics of foliar fungicide applications in winter wheat in Northeast Texas', Crop Protection, 67, 35–4

Majumder M 1991. Crops of Eastern Indian. West Bengal stage Book Board. Arg. Manson (8th floor) 6/A, Raja Subodh Mallik square, Calcutta p. 85.

Malakar PK. 2003. Studies on black point (*Bipolaris sorokiana*) of wheat and its management. Ph.D. Thesis. Department of Plant Pathology, BSMMU, Gazipur, Bangladesh.pp.13-30.

Me Carty SC, Chauhan DS, MeCarty AD, Tripathi KM and Selvan T. 2017. Effect of *Azotobacter* and *phosphobacteria* on yield of wheat (*Triticum aestivum*). Vegetos-An International Journal of Plant Research, 30(2).

Mokula Mohammed Raffi, Mokula Mohammed Raffi, PBBN. Charyulu SriKrishnadevaraya University, University of Gondar 01 jan ,2021. (Academic Press) - pp 193-209

Mondol H. 2000. Effect of seed and soil borne inoculate of *Bipolaris sorokiana* on seedling mortality and spot blotch of wheat. M.S. Thesis. Department of plant pathology, BSMMU, Gazipur.pp:32.

Nagaraja H, Chennappa, G Deepa N, Naik MK, Ajithkumar K, Amaresh YS, Achar P, and Sreenivasa MY. (2022). Title of the article. *Journal of Fungi, 8*(5), 473. https://doi.org/10.3390/jof8050473

Nagarangan S and Kumer J. 1998. Foliar blights of wheat in India: germplasm improvement and future challenges for sustainable high yielding wheat production . In: Duveiller E, Dubin HJ, Reeves J and McNab A (eds) Proc. Int. Workshop helminthosporium Diseases of wheat: Spot Blotch and Tan Spot, 9-14 February 1997, CIMMYT, EI Batan, Mexico, DF.pp.52-58.

Nazmun Ara N, Rokonuzzaman M, and Hasan MN.2009. Effect of Bradyrhizobium and *Azotobacter* on growth and yield of mungbean varieties. *Journal of the Bangladesh Agricultural University*, 7(1).

Ojaghloo FF. Farahvash A. Hassan-Zadeh and M Pour-Yusef. (2007). Effect of inoculation with *Azotobacter* and barvar phosphate biofertilizers on yield of safflower (*Carthamus tinctorius L.). Journal of Agricultural Sciences, Islamic Azad University, Tabriz Branch 3: 25-30.*

Ozer N. 2005. Determination of the fungi for black point in bread wheat and effects of disease on emergence and seedling vigour. Trakya University Journal of Science.6:35-40.

Panna R, Aminuzzaman FM, Islam MR and Bhuiyan MB.2009. Evaluation of some Physical Seed Treatment against (*Bipolaris sorokiana*) associated with wheat seeds.

Paradeshi BM, Mhaske KD, Bhoite G, Bhangale T and Rasal PN. 2008. Effect of foliar fungicides on Black point of wheat. Agricultural Science Digest.28(3):227-228.

Patel PR, Patel BJ, Vyas KG and Yadav BL.2014. Effect of integrated nitrogen management and bio-fertilizer in Kharif pearl millet (*Pennisetum glaucum* L.). *Advance Research Journal of Crop Improvement*, 5(2): 122-125.

Pathak AK, and Godika S. 2010. Effect of organic fertilizers, biofertilizers, antagonists and nutritional supplements on yield and disease incidence in Indian mustard in arid soil. *The Indian Journal of Agricultural Sciences*, 80(7).

Rahman GMM and Islam MR. 1998. Effect of black point of wheat on some qualitative character of its grains and seed vigour. Bangladesh Journal of Agriculture Research. 23(2):283-287.

Rashid AQMB, Lahiri P and Islam T. 1994. Effect of *Bipolaris sorokiana* some yield components and seed quality of wheat. Bangladesh Journal of Agriculture Sciences. 21:185-192.

Reza MMA, Khalequzzaman KM and Rashid AQM. 2006. Effect of different levels of black pointed seed and plant infection by *Bipolaris sorokiana* on wheat. Bangladesh Journal of Agriculture and Research.31(2):241-248.

Romero-Perdomo F, Abril J, Camelo M, Moreno-Galván, A, Pastrana I, Rojas-Tapias D, and Bonilla R. 2017. *Azotobacter* chroococcum as a potentially useful bacterial biofertilizer for cotton (*Gossypium hirsutum*): Effect in reducing N fertilization. *Revista Argentina de microbiologia*, 49(4), 377-383.

Sen A. Poverty and famines: an essay and entitlement and deprivation. Oxford: Clarendon; 1982.

Shabeer A and Bochus WW. 1998. Leaf spot effects of yield and yield components relative to growth stage in winter wheat. Plant Disease 72(2);599-602.

Shahidullah MS. 2006. Avoidable yield loss due to *Bipolaris* leaf blight of wheat and its management M.S. Thesis. Department pf Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh.

Shamim I, Shahazd A, Anjum M, Amir S and Iftikhar A. 2009. Hosts of *Bipolaris sorokiniana* the major pathogen of spot bloch of wheat in Pakistan. Pak.J. Bot,41(3):1433-1436.

Sharma P, Duveiller D and Sharma E. 2005. Effects of seed treatment and foliar fungicides on Helminthosporium Leaf Blight and performance of wheat in warmer growing conditions. Journal of Phytopathology 153:401-408.

Sharma RC and duveiller E.2007. Advancement toward new spot blotch resistance wheats in South Asia. Crop Sci.47:961-968.

Singh NK, Chaudhary FK and Patel DB. 2013. Effectiveness of *Azotobacter* bio-inoculant for wheat grown under dryland condition. Journal of Environmental Biology, 34(5), 927.

Singh R V. Singh AK, Ahmad R and Singh SP. 1998. Influence of agronomic practices on foliar blight and identification of alternate hosts in the rice-wheat cropping systems. In: Helmonthosporium blights of wheat spot blotch and tan spot (E Duveiller, E, HJ Dubin, J Reeves and AMchab, eds). CIMMYT, Mexico, D.F.

Singh R, Sengar RMS and Singh S.2012. Incidence of Foliar Blight Pathogens of wheat. In Agro Region. Indian Journal of Science .1(2):39-41.

Sobhan R. 1979. Politics of food and famine in Bangladesh. Economic and Political Weekly14: 1973–1980

Soleimani R and Nourgholipour F. 2023. Humic acid fertigation and *Azotobacter* priming improve the nutritional quality of wheat grain and flour. Journal of Plant Nutrition, 46(7), 1344-1353.

Soleimanzadeh H, and Gooshchi F. 2013. Azotobacters as biofertilizer. Advances in Applied Microbiology, 37, 1-43.

Sultana A and Rashid AQMB. 2012. Effect of seed category as affected by *Bipolaris sorokiana* on the germination of wheat seeds. J. Environ. Sci. Natural Resources.5(1):44-47.

Sumbul A, Ansari RA, Rizvi R and Mahmood I 2020. Azotobacter: A potential bio-fertilizer for soil and plant health management. Saudi Journal of Biological Sciences, 27(12), 3634-3640.

Tan LP, Samsuddin AS and Lee S. H. 2019. Universiti Malaysia Kelantan, Universiti Putra Malaysia. Springer, Cham, 23–41.

USDA, 2006. According to USDA (United States Department of Agriculture)

Vijay Kumar, Poonam SK Sharma, Minakshi Thakur 25 nov, 2019 (ERESEARCHCO)- Vol. 05, Iss: 02, pp 41-47.

Wani SA, Chand S, Wani MA, Ramzan M, and Hakeem KR. 2016. "*Azotobacter chroococcum* - a potential biofertilizer in agriculture: an overview," in Soil Science: Agricultural and Environmental Prospectives, eds KR Hakeem, J Akhtar and M Sabir (Cham: Springer), 333–348.

Zaman R, Aminuzzaman FM, Islam MR and Chowdhury R. 2010. Eco-friendly seed treatments in controlling black point (*Bipolaris sorokiana*) of wheat. International Sustainable Crop production.5:35-42.

Zobaer ASM, Aminuzzaman FM, Chowdhury MM and Miah MS.2007. Effect of seed sorting, solarization and treatment with vitavax-200 and hot water on leaf spot disease and yield of wheat Bangladesh Journals of Seed Science and Technology.11:11-15.