EFFECT OF FERTILIZER AND PLANT GROWTH REGULATOR ON LEAF BLIGHT OF WHEAT

A THESIS

BY

Kawser Jahan
Student No.: 2305008
Session : 2023-2024
Thesis Semester: January – June 2024

MASTER OF SCIENCE (MS)
IN
PLANT PATHOLOGY

DEPARTMENT OF PLANT PATHOLOGY

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Submitted to the
Department of Plant Pathology
Hajee Mohammad Danesh Science and Technology University, Dinajpur
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE (MS)

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Approved as to style and content by :

Professor Dr. Sheikh Md. Mobarak Hossain
Supervisor

Dr. S.M. Emdadul Hassan
Co-Supervisor

Professor Dr. Mohidul Hasan
Chairman, Examination Committee
&
Chairman, Department of Plant Pathology

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY, DINAJPUR-5200

JUNE 2024

DEDICATED TO

MY

BELOVED PARENTS

ACKNOWLEDGEMENTS

The author is deeply grateful to "Almighty Allah", the Creator and Sustainer of the universe, for His mercy and His never ending blessing to successfully complete this research work and prepare this thesis for the Master of Science (MS) degree in Plant Pathology.

The author would like to express her deepest respect and gratitude to her beloved and revered teacher and ***Supervisor Prof. Dr. Sheikh Md. Mobarak Hossain,*** *Department of Plant Pathology (PLP), Hajee Mohammad Danesh Science and Technology University, HSTU, Dinajpur. His unwavering guidance, valuable suggestions, warm encouragement, insightful comments, constructive criticism, and continuous supervision were instrumental in carrying out this research work and preparing this manuscript.*

The author is pleased to express her sincere appreciation and heartfelt thanks to his respected ***Co-Supervisor Dr. S.M. Emdadul Hassan,*** *Professor of the Department of Plant Pathology (PLP), HSTU, Dinajpur. His friendly support, constructive criticism, valuable advice, immense co-operation, and scholarly advice were invaluable during the research work and the preparation of the thesis paper.*

The author expresses her sincere gratitude towards the Chairman, ***Professor Dr. Mohidul Hasan****, Department of Plant Pathology (PLP), HSTU, Dinajpur. The author likes to express her deepest sense of gratitude to* ***Dr. A. T. M. Shafiqul Islam, Professor Dr. Md. Mamunur Rashid, Associate Professor Md. Mukul Islam., Lecturer Md. Ahsan Habib, Lecturer Md. Mobinul Islam*** *of the Department of Plant Pathology, Hajee Mohammad Danesh Science and Technology University, Dinajpur, for their valuable suggestions, instructions, cordial help and encouragement during the period of the study.*

The author extends her thanks to all the staffs and officials of the Department of Plant Pathology, HSTU, Dinajpur and for their excellent co-operation during the research work.

The author expresses her sincere appreciation to her class fellows and friends especially Mita Saha Puja and Abu Raihan Rono for their inspiration, help and encouragement throughout the study period. Their constant co-operation, affectionate feelings and inspiration were a great source of motivation throughout the research work.

Finally, the author deems it a great pleasure to express her profound thankfulness to her beloved brother and respected parents, who entiled much hardship inspiring for prosecuting her studies, receiving proper education. Their blessings and inspirations were her guiding light throughout her entire period of study.

ABSTRACT

A field experiment was conducted at the research field of Agricultural Research Station (BARI), Dinajpur during period of December 2023 to April 2024 to evaluate the effect of fertilizer and PGR application on leaf blight disease of wheat. Randomized complete block design with four replications and five treatments was followed for the experiment. The variety of BARI Gom 33 was used in this experiment. The treatments used in the experiment were T_1:100% FRG recommended dose (control), T_2: FRG recommended dose (100% urea+85% TSP +100% MoP) + ROOTOPEX, T_3: FRG recommended dose (100% urea+75% TSP +100% MoP) + ROOTOPEX, T_4: FRG recommended dose (100% urea+50% TSP +100% MoP) +ROOTOPEX and T_5: Farmers practice (650g urea+550g TSP+450g MoP). In this experiment after 95 DAS, percentage of disease leaf area and severity both were found the highest at T_1. In case of percentage of normal seeds, T_2 showed the highest result having 73.75% where Rootopex was applied. Percentage of undersized seeds were recorded the highest at T_1 having 20.50%. On the other hand, percentage of broken and black pointed seeds were found the highest at $T_{5.}$ In case of total number of grains per spike, T_2 showed the highest percentage. About yield, the highest amount noted at T_2 having 12.32kg/plot . In case of seed health seeds, seeds from Rootopex applied plot showed very impressive result like the highest percentage of germination recorded at T_2 having 92%. When it comes to percentage of pathogen associated with seeds, T_5 showed maximum valued. In this experiment fertilizer combined with plant growth regulator (PGR) showed positive response among maximum parameters.

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AEZ	: Argo Ecological Zone
CV	: Co-efficient of Variation
DAS	: Days After sowing
DI	: Disease Incidence
DS	: Disease Severity
FRG	: Fertilizer Recommendation Guide
LSD	: Least Significance Difference
PLP	: Plant Pathology
PGR	: Plant growth regulator
RCBD	: Randomized Complete Block Design
SRDI	: Soil Resource Development Institute

Chapter I

Introduction

Wheat (*Triticum aestivum L.*) is one of the most nutritious, proteinaceous and basic stable food crop in the world. Actually it is an annual grass which is ½ to 1 ¼ meters in height with a long stalk that formed cluster of plump kernels enclosed by a bread of bristly spikes. Along with corn and rice, it is grown all over the world for its highly nutritious value. Based on data sourced from FAOSTAT (2005), wheat was planted globally, yielding approximately 600 million tons of grain from an area covering 220 million hectares. The average yield from a single acre is approximately 2.5 tons that use for Human food, animal feed and seed for planting and processing for industrial uses in worldwide. Cereal consumption is rising daily over the world. It is predicted that by 2050, the developing world's demand for grains will have climbed by 60% from 2000 levels. Throughout the same time period, there will be a 26% growth in the demand for wheat.

In Bangladesh, wheat is the second-most important grain crop after rice. This crop grows in Bangladesh during the Rabi (Winter) season which runs from mid-November to mid-March. It needs dry weather, strong sunlight, and evenly spaced rainfall between 40 and 110 cm to grow in a friendly manner. It is contributing significantly to achieving national food and nutritional security. In less than 40 years, wheat has solidified itself as a reliable crop in Bangladesh. In Bangladesh's average wheat production is lower than that of other nations. The total amount of wheat produced in 2015–16 and 2016–17 from 0.445 and 0.415 million hectares of land was 1.348 and 1.311 million tons (BBS, 2017). Eighty percent of the 5.5 million tons of wheat required annually are imported by the nation. Only 20% of the country's wheat needs could be satisfied by the 1.15 million tons of wheat produced from 0.33 million ha in 2018–2019.

Wheat provides over half of the food calories consumed globally and is high in minerals (Cu, Mg, Zn, P, and Fe), vitamins (B-group and E), dietary fiber, riboflavin, niacin, and thiamine, as well as proteins (gluten). Its agronomic versatility, nutritional composition, ease of storage and transportation, and quick conversion into flour are some of the main reasons it is essential to human diets (Oleson and Ranhotra 1996). According to Shiferaw *et al*. (2013) maize (*Zea mays*) accounts for 5% of daily dietary calories consumed by humans worldwide, whereas wheat makes up 20%, Rice makes for 19%. Additionally, wheat is the most significant source of protein in the world, accounting for around 21% of daily protein intake in humans. It is mainly used for preparation of bread, biscuits, cookies, cracks, noodles, vermicelli etc. Wheat straw is used for the animal food as fodder, for packaging materials and so many other utilization. It is also contribute more calories and protein to the worlds diet than any other food crop. It contains nearly carbohydrates 70%, protein 12%, fat 1.7%, minerals 2.7%, fiber 2% and moisture 12%. Now a days wheat as a good supplement of rice that plays a vital role to cover the food demand and placed as second most important cereal crop in Bangladesh (Adhikary *et al*. 2015). According to estimates, in order to match the demand and supply chain in 2050, agricultural commodities should expand by 50% due to the global population's daily growth. However, the main obstacles in this race are biotic and abiotic variables, which have an annual impact on productivity. Climate change is one of the man-made variables that contribute to abiotic factors. Insects, pests, weeds, and major disease pathogens are examples of biotic forces. The production and quality of grain decrease annually as a result of these variables. Different diseases are major threat to wheat production in changing climatic scenario (Chowdhury *et al*. 2014). Wheat crop is affected by many fungal diseases. There are around 200 wheat diseases in total, but only 50 of them are economically significant and are found in large areas (Wiese 1987, Al-Sadi 2016, Jarroudi *et al.* 2017, Lalic *et al*. 2017, Riaz *et al*. 2017, Sharma *et al*. 2017). Diseases cause the loss of 20% or more of wheat annually. Major wheat diseases include blast, fusarium head blight, rusts, spot blotch, common root rot, smut, tan spot, Septoria blotch, powdery mildew, and several bacterial, viral, and nematode diseases (Wiese 1987,Chowdhury *et al*. 2013, Fetch *et al*. 2015, Zhu *et al*. 2015, Al-Sadi 2017, Abdullah *et al*. 2020, Aboukhaddour *et al*. 2020, Gultyaeva *et al*. 2020). They may lower output or cause the afflicted plants to die. The leaf blight of wheat is one of the most harmful diseases that affect wheat and cause large crop losses globally. The *hemibiotrophic*, phytopathogenic fungus *Bipolaris sorokiniana* is the cause of the leaf blight disease, which is prevalent in warmer and more humid regions of the world (Joshi *et al*. 2007). According to Chand and Joshi (2004), *B. sorokiniana* typically causes symptoms on the leaf, sheath, and stem. A variety of meteorological factors influence the disease's significance for wheat. When there are multiple days of high humidity, cool temperatures (15–25°C), a lot of rain and plants are more susceptible at the boot stage, the illness is more frequently reported. The use of fungicidal and biological control, clean cultivation away from sources of resistance, crop rotation with appropriate fertilization, and other IPM techniques can help reduce disease levels.

Fungicides were typically used by farmers to try and manage this disease. Fungicides have shown promise in the management of tan spot (Loughman *et al*. 1998) and spot blotch (Viedma and Kohli, 1998), even though the use of pesticides should be avoided. However, we are aware of the extent of fungicides' impact to both people and the environment. Therefore, we make an effort to regulate it by improving nutritional development. In order to enhance wheat (*Triticum aestivum L*.) yield and harvestability, cultivators are employing plant growth regulators (PGR) and raising nitrogen rates. Wheat crop characteristics including biomass, number of grains and overall yield are greatly influenced by plant growth regulators. The application of PGRs foliarly was also shown to greatly extend the grain filling period, leading to an increase in grain weight and kernel size (Arfan *et al*. 2007). This is because the photosynthetic rate has increased (Fariduddin *et al*. 2003). Researchers have shown that using PGRs in conjunction with nitrogen fertilizer can boost wheat output by about 20% (Shekoufa and Emam, 2008). Bio-fertilizers and plant growth regulators (PGRs) enhance plant efficiency, including photosynthetic capabilities, leading to increased agricultural yields. Pseudomonas species can serve both as PGR and in phytopathogen control due to their ability to secrete particular chemicals with key roles in phosphate solubilizing compound formation, siderophore generation, and nitrogen fixation as part of their plant growth-promoting activities.

From the above discussion, a research work was undertaken on the following objectives :

- To know the effect of Rootopex against leaf blight disease of wheat .
- To observe the effect of Rootopex on the yield of wheat

Chapter II

Review of Literature

Bipolaris sorokiniana (teleomorph, *Cochliobolus sativus*) is one of the wheat diseases that can affect any wheat portion including seeds, roots, shoots, and leaves. This section provides the relevant studies that are related to the current research :

2.1 Bipolaris blight disease of wheat

Zillinsky (1983) and Mishra *et al*. (2001) stated that the fungus known as *Bipolaris sorokiniana* (Sacc.) Shoemaker (also known as *Helminthosporium sativum Pamm*., King & Bakke) is primarily responsible for non-specific foliar blight, but it can also cause crown rot, seedling blight, head blight, blackpoint disease in wheat and seed rot or germination failure.

Dubin and Van Ginkel (1991) and Duveiller and Gilchrist (1994) explained that *Bipolaris sorokiniana* (teleomorph, *Cochliobolus sativus*) is one of the most serious foliar diseases restricting wheat productivity in warmer, unconventional growing locations.

According to Malik *et al*. (2008) this disease can result in yield losses of up to 50% and a decline in seed quality.

2.2 Leaf Blight Pathogen "*Bipolaris sorokiniana*": Taxonomy and Nomenclature

Maraite *et al.* (1998) clarified that the anamorph *B. sorokiniana* has been referred to by a number of synonyms in previous literature, which comprise the following: *Cochliobolus* *sativus,teleomorph Helminthosporium sativum, H. sorokinianum, Drechslera sorokiniana, and Drechslera prorokiniana* .

Shoemaker (1959) proposed the genus name Bipolaris for *Helminthosporium* species having fusoid, straight, or curved conidia that germinate through two germ tubes, one from each of the two ends (bipolar germination).

According to Rossman *et al.* (2013) when a *Helminthosporium* species with fusoid conidia exhibiting bipolar germination was first characterized as Bipolaris in 1959, species B. *maydis* was regarded the genus' typification. The International Fungal Taxonomy Committee recently conducted an online poll in support of the request to preserve the word *Bipolaris* rather than *Cochliobolus*.

The conidia and conidiophores of *Bipolaris/Cochliobolus species* differed significantly. The shape and color of teleomorphic ascospores in the Cochliobolus genus, which includes C. *heterostrophus* and C. *sativus* were less notable. Multiple investigations using molecular data have shown that the sexual form of B. *sorokiniana* is similar to *Cochliobolus sativus*. The analysis of ribosomal DNA polymorphism, including 28S rRNA, 5.8S rRNA, and internal transcribed spacers (ITS1 and ITS2), as well as protein-coding barcoding genes like GAPDH and elongation factor 1α, supports the idea that B. *sorokiniana* and *Cochliobolus sativus* are two stages of the same species.

Kumar *et al.* (2020) supported B. *sorokiniana* as the recognized nomenclature for Cochliobolus, which is common in South Asia but dominated by B. *sorokiniana*.

Gupta *et al.* (2018) stated that the genus Bipolaris belongs to Division Ascomycota, Sub-Division Loculoascomycete, Class Dothideomycetes, Order Pleosporales, and Family Pleosporaceae.

2.3 Symptoms of Bipolaris Leaf blight

According to Acharya *et al*. (2011) the earliest physically noticeable signs appear as 1-2 mm-sized lesions that begin to emerge on leaves.

As per the findings of Gupta *et al*. (2018) brown-colored lesions initially form with yellow halos surrounding them.

Chand *et al*. (2002) said that lesions on leaves begin as a few mm and grow into lengthy, dark brown blotches that are larger than 1-2 cm.

Mercado Vergnes *et al*. (2006) and Bockus *et al.* (2010) noted that an abundant generation of conidia can be noticed on old lesions in humid conditions, and a chlorotic stripe is sometimes seen diffusing from the edge of the lesion as a result of toxin production.

2.4 Pathogenic variability and host range

Reis (1991) claimed that Infected seeds, infected crop leftovers, collateral hosts, and free dormant conidia in the soil are the natural sources of B. *sorokiniana* inoculum.

Shaner (1981) stated that infected seed seems to be the primary source of inoculum.

Spurr and Kiesling (1961) reported that after sowing, the fungus begins to grow on the wet seed. Direct sunlight induces sporulation as early as the first leaf stage.

Burgers and Griffin (1968), Reis and Wunsche (1984) stated that the fungus's capacity to colonize sick wheat straw allows *B. sorokiniana* to survive in soil, and the pathogen's inoculum density in soil is correlated with the quantity of sporulation that occurs in crop wastes.

Mondal (2000) reported that contaminated seeds and soils containing either conidial suspension or colonized grains could be potential sources for *B. sorokiniana* to survive, which could lead to germination failure, seedling death, and the formation of spot blotches in wheat.

According to Prem Naresh *et al.* (2009) at pH 6.5, good sporulation occurred and 28^0 C was the ideal temperature for both growth and sporulation. Richard medium was shown to enable optimal growth.

Acharya *et al.* (2011) described that *Bipolaris sorokiniana* conidiophores are unbranched, brown to dark brown, erect, single or clustered, septate, and conidia are brown to olivaceous brown in color, straight or slightly curved, 50-70µ long 15-20µ wide, with 3-7 septation variations.

According to Hobbs and Morris (1996) , Manamgoda *et al*. (2011) and Singh *et al.* (2016) this pathogen can infect the following crops: Durum wheat (*T. dicoccum*), barley (*Hordeum vulgare*), triticale (*Triticosecale*), rye (*Secale cereale*), maize (*Zea mays*), pearl millet (*Pennisetum typhoides*), foxtail millet (*Setaria italica*), tufted airplant (Guzmania species, Tillandsioideae), Panicum sp., Phleum pratense, and Phalaris minor, as well as a variety of other wild grasses.

Acharya *et al*. (2011) mentioned that *B. sorokiniana* is an opportunistic hemi-biotrophic pathogen that lives a biotrophic lifestyle before infection but can become necrotrophic once within the host body.

Mann *et al.* (2014) used polymerase chain reaction (PCR) with universal rice primers (URP) to isolate and test 60 monosporic *B. sorokiniana* isolates from Brazil and other countries. This allowed for molecular characterisation and identification of pathogen diversity.

Christensen (1925) and Tinline (1962) indentified that *B. sorokiniana*, the spot blotch pathogen, as a flexible fungal species that exhibits numerous morphological and physiological variations.

Tinline (1958) clarified that hetrokaryosis and the parasexual process have been given partial credit for the diversity.

Hetzel *et al*. (1991) and Jeger (2004) outlined this pathogen appears to be becoming more unpredictable and aggressive with time.

Chand *et al.* (2003) found distinct physical characteristics among the five groups of *B. sorokiniana* isolates. Rasmussen *et al.* (2003) also found that the durability of resistant genetic strains is crucial when dealing with *B. sorokiniana*, the primary pathogen which has a variety of strains.

Mishra and Chourasia (1976), Reis and Santos (1987), Reis (1989), Reis *et al.* (1998) and Duczek *et al.* (1999) stated that numerous researchers have attempted to ascertain the viability of *B. sorokiniana* spores and the degree of their survival in soil and crop residues under various circumstances.

2.5 Toxin production

Ludwig (1957) and Gayad (1961) noted that a few early reports showed phytotoxic compounds to be present in B. *sorokiniana* culture filtrate.

Gayad (1961) declared different *Bipolaris sorokiniana* strains have been identified and the least virulent isolates of this fungal pathogen have been found to exhibit distinct symptoms on wheat genotypes when culture filtrates of the pathogen are used. These distinctions are based on morphological, physiological and genetic bases.

Kachlicki (1995) and Turner & Aldridge (1983) explained approximately twenty chemicals similar to helminthosporol have been isolated from several species of the genus Bipolaris.

According to Carlson *et al*. (1991) *B. sorokiniana* produces 1.2-2.1 µg/mg dry matter of fungal tissue, which is its most abundant and active component.

According to studies conducted by Aggarwal *et al.* (2008) and Jahani *et al*. (2014) toxin bipolaroxin is produced by various isolates of B. *sorokiniana* in the range of 0.05 µg/ml to 0.72 µg/ml culture filtrate.

2.6 Disease Cycle and Epidemiology of the Disease

According to Singh and Srivastava (1997) most Helminthsporium species like mild to warm temperatures (18–32 °C), especially when it's humid outside**.**

Reis (1991) asserted that the pathogen is present both outwardly and inside as conidia and internally as mycelium in the seeds or as in infected crop wastes, volunteer plants, secondary hosts and free dormant conidia in soil.

Couture and Sutton (1978) found that symptoms peak when leaves are wet for more than 18 hours with a mean temperature over 18˚ C.

According to Acharya *et al.* (2011) the infection for spot blotch begins with the attachment of conidial spores to the leaf surface, followed by their germination and the production of germ tubes.

Jansson and Akesson (2003) decleared that within 8 hours, the germ tubes enlarge enough to form an appressorium, from which infectious hyphae grow.

Sahu *et al.* (2016) and Acharya *et al.* (2011) explained that the hyphae penetrate the host's cuticle within 12 hours and multiply rapidly, penetrating into the intercellular space within the mesophyll tissue of the leaf.

Acharya *et al*. (2011) claimed that several cycles of conidia formation are conceivable during the cropping season, causing secondary infections involving conidia spread by dew and rain.

Chand *et al*. (2002) and Pandey *et al*. (2005) shown that the fungus can persist on straw or in the soil for several months before its viability begins to deteriorate.

Chand *et al*. (2002) reported it has been observed that the conidia found on wheat straw tend to congregate into clumps after 5 months of storage.

According to Sharma and Duveiller (2003) the choice of tillage, irrigation schedule, soil fertility, sowing density, crop growth stage, occurrence of late rains during crop cycle, heat stress during grain filling, late planting, high temperature and high relative humidity causing more than 12 hours duration of leaf wetness are all factors that directly affect how severe the disease is.

According to Duveiller *et al.* (2005) epidemiological research has demonstrated that prompt seeding helps prevent the physiological stress that frequently occurs during the flowering period, which in turn lessens spot blotch.

Sultana (2018) reported that *B. sorokiniana* in South Asia adopted warmer temperatures during the 20th century, which led to the emergence of extremely virulent isolates in high ganges river flood plain agro-climatic zones.

Sharma and Duveiller (2003) stated that the following factors directly affect the severity of the disease: the choice of tillage, irrigation scheduling, soil fertility level, sowing density, crop growth stage, occurrence of late rains during crop cycle, heat stress during grain filling, late planting, high temperatures and high relative humidity causing more than 12 hours duration of leaf wetness

Acharya *et al*. (2011) found that wheat spot blotch has arisen as a major problem for wheat farming in warmer and more humid locations of the world. Disease severity was said to be directly proportional to humidity, temperature, and soil nutrient status. The highest yield loss occurred when the flag leaf and the leaf beneath it became infected before to the development of the head.

2.7 Yield losses

According to Alam *et al*. (1994) severe losses were estimated to reach 15% on multiple farms in Bangladesh over a period of years due to this disease.

Singh *et al*. (2007) stated that because spot blotch reduces 1000-grain weight and grain yield, it has been regarded as a significant barrier to wheat yields in South Asia.

Sharma *et al.* 2005 indicated that grain infections by this fungus in years that were favorable for the disease were detected to be up to 70%.

Saari (1998) confirmed through pathogenicity testing that *Bipolaris sorokiniana* caused a severe disease foliar blight/spot blotch of wheat and was able to minimize yield losses by 16-23%.

Malik *et al.* (2008) claimed that the disease is known to result in yield losses of up to 50% and a decline in seed quality.

2.8 Disease Management

According to Kumar *et al*. (2021) and Chakraborty *et al*. (2021) new and trustworthy technologies are being created for the management of *B. sorokiniana*, as it has become a serious pathogen in recent years.

Krupinski and Tanaka (2000) and Singh *et al*. (1998) explained that changing mineral nutrients may prevent foliar blight through agronomic methods in different countries.

Sharma *et al*. (2006) explained good crop husbandry and appropriate agronomy may also lower spot blotch disease intensity up to a certain point.

Duveiller *et al.* (2005) demonstrated that early seeding minimizes physiological stress, which frequently occurs during the flowering stage, hence reducing spot blotch.

Sharma *et al.* (2006) discovered that a balanced application of nitrogen, phosphorus, and potassium reduced spot blotch severity by 15 and 22%, respectively.

Stack and McMullen (1988) and Mehta (1993) reported that Various fungicide seed treatments, including as captan, mancozeb, maneb, thiram, pentachloronitrobenzene (PCNB), carboxin, iprodione, and triadimefon, can prevent leaf blight

Mandal *et al.* (1999) discovered that Trichoderma reesei and Chaetomium globosum significantly inhibited the radial growth of *Bipolaris sorokiniana.*

2.9 Importance of Plant growth regulators

According to Verma *et al*. (2016) and Takahashi *et al*. (2019) plant growth regulators (PGRs) are naturally biosynthesized by plants and play a crucial role in mitigating abiotic stresses by modifying plant growth (branching, shoot and root growth, fruit maturation, reproduction etc.

Dahnous *et al.* (1982), Green (1986) and Rademacher (2015) stated that plant growth regulators (PGRs) are used internationally in many crop species to impart a number of effects including increased yield, breaking of bud dormancy, fruit maturation prevention or initiation, plant height management, and lodging mitigation.

Akram *et al*. (2017), Ma *et al*. (2017) and Sharma *et al*. (2020) declared that PGRs play a significant role in stress conditions by acting as thermo protectants, reactive oxygen scavengers, enhancing photosynthesis, accumulating stress proteins, and carrying out numerous other metabolic regulatory tasks.

Adesemoye *et al*. (2008), Tutuja and Sopory (2008), Berens *et al*. (2019), Raza *et al*. (2019) and EL Sabagh *et al*. (2021) claimed that in order to detect external signals and respond optimally to stressful conditions, plants have developed sophisticated mechanisms that are supported by PGRs. These PGRs primarily regulate the defensive responses of plants through antagonistic and synergistic activities or "signaling crosstalk"

Rostami and Azhdarpoor (2019) stated that the use of PGRs, specifically gibberellins, auxins, salicylic acid and cytokinins is regarded as one of the key mechanisms involved in phytoremediation of contaminated soil. Even though their actions are influenced by environmental conditions and concentrations, which affect their assimilation and the plant's physiological condition.

Stover and Greene (2005) and Bons and Kaur (2020) stated that although there have been differences in crop responses to PGR foliar treatment, this is partly because of environmental factors including high humidity and periods after rain, which may reduce their effectiveness.

Uddin *et al.* (2009) claimed that Plant growth regulators or PGRs are synthetic compounds that can be used to change a plant's maturity, increase branching, reduce shoot growth, increase return bloom or remove excess fruit.

Chapter III

MATERIALS AND METHODS

This chapter provides a detailed description of the supplies and procedures used in this experiment to meet its goals. This chapter is organized into various sections for ease of reading, including site and soil, crop, land preparation, treatments, fertilizer application, fertilizer application, data gathering, harvesting, and statistical analysis.

3.1 Experimental site

The experiment was conducted at Agricultural Research Station (BARI), Dinajpur.

3.2 Experimental period

The experiment was carried out December 2023 to April 2024.

3.3 Soil type

The Himalayan Piedmont Plain (AEZ-1) is the source of the soil in the trial area. The experimental plot's soil was sandy loam with adequate drainage capacity, according to soil analysis.

3.4 Variety used in the experiment

BARI GOM 33 was considered for the experiment.

3.5 Main features of the variety

This variety was developed by Wheat Research Centre (WRC), Bangladesh Agricultural Research Institute (BARI), Gazipur, Bangladesh.

3.6 Source of treatments

Treatments were collected from local market of Dinajpur and PGR (Rootopex) were collected from Apex Biofertilizers and Biopesticides Ltd.

3.7 Treatments

ROOTOPEX

T_1 : 100% FRG recommended dose (control)

T_2: FRG recommended dose (100% urea+85% TSP +100% MoP) + ROOTOPEX

T_3: FRG recommended dose (100% urea+70% TSP +100% MoP) + ROOTOPEX

T_4: FRG recommended dose (100% urea+50% TSP +100% MoP) +ROOTOPEX

T_5: Farmer's practice (650g urea+ 550g TSP+ 450g MoP)

3.8 Replication

In this experiment, four different types of replication were used.

3.9 Experimental procedure and crop management

3.9.1 Field Preparation

After a week of sun exposure, the chosen experimental plot was opened using a power tiller. A nice tilth was achieved after two days of harrowing, plowing, and repeatedly cross-plowing the field, followed by laddering. Finally, a suitable soil tilth was achieved for planting the wheat seeds after weeds and stubbles were cleared.

3.9.2 Seed sowing

As per the experimental layout, seeds were sowed in line on December 9, 2023 after the line spacing was prepared.

3.9.3 Experimental design and layout

The experiment was laid in a Randomized Complete Block Design (RCBD) with four replications. Each replication was first divided into five (5) experimental plots according to the treatments randomly. Thus, the total number of unit plots was 20 (5×4=20). The size of a unit plot was 5m ×4m = 20m^2. The distance was maintained between plot to plot was 1m.

3.9.4 Fertilizer and fungicide application

The following doses of fertilizers were applied to the plots are described in Table:

Fertilizer	**Treatment**				
	T_1	T_2	T_3	T_4	T_5
Urea	352 g	352 g	352 g	352 g	650g
TSP	162 g	138 g	114 g	81 g	550g
MOP	243 g	243 g	243 g	243 g	450g
Gypsum	169 g	169 g	169 g	169 g	300g
Zinc	13 g	13 g	13 g	13 g	30g
Mg	85 g	85 g	85 g	85 g	----
Boron	18 g	18 g	18 g	18 g	30g

Fungicide application:

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

3.9.5 Seed treatment

After apply a homogeneous layer of ROOTOPEX to the wheat seeds, allow them to dry for 15 to 20 minutes in the shade and then sow them as soon as possible. (Precaution: The treated seed should kept in a cool, dry and shady place. The seeds should be covered with soil as soon as they are sown)

3.9.6 Soil Application

Before the last phase of land preparation, thoroughly combine ROOTOPEX with organic matter, store in the shade for the entire night, and then spread

out over the soil. (Precaution: Should be used 24-48 hrs after chemical fertilizer application and should not use any chemical pesticides for 7days after the application).

3.9.7 Intercultural operations

Intercultural operations were done to ensure the normal growth of the crop. Plant protection measures were followed when necessary. The following intercultural operations were followed:

3.9.8 Irrigation

After the seedlings had grown and developed properly, irrigation was applied as needed. From the time of head formation until the head maturity phase, care was made to prevent water stress. This process should be performed every 20–30 days for improved output.

3.9.9 Weeding

Several common weeds including Batua (*Chenopodium album*), Durba (*Cynodon dactylon*), Mutha (*Cyperus rotundus*), Shetodrone (*Leucas aspera*) and Sushni Shak *(Marsilea quadrifolia*) were invaded in the plots. These were manually removed from the field close to roughly three times throughout the farming season.

3.9.10 Tagging

Tagging was performed to separate different plot of different varieties of treatments and replications.

3.10 Data Collection

Data on different morphological characteristics were recorded following guidelines based on visual observation and represented into appropriate categories.

Data collection based on yield and yield characteristics:

3.10.1 Growth parameters

- Plant height (cm)
- Number of plants per plot
- Leaf length and leaf breadth (cm)
- Spike length (cm)

3.10.2 Disease related parameters

- Disease incidence
- Disease severity

3.10.3 Yield related parameters

- Number of grains per spike
- Yield (kg/plot)
- 1000 grain weight (g)

3.11 Procedure of data collections

3.11.1 Plant height (cm)

Ten plants were randomly selected from each plot to measure the plant height in cm and average plant height was calculated. A meter scale was used to measure the plant height.

3.11.2 Leaf Length and breadth (cm)

Plants were randomly selected from each replication to count the length and breadth of leaves per plant and average length per plant were calculated.

3.11.3 Spike length (cm)

Randomly selected plants from each were used to measure the spike length. Spike length was measured from basal node of the spike to the apex of the awn. Spike length was taken at 95 DAS. It was recorded in cm.

3.11.4 Thousand grain weight (g)

Thousand grains were counted per plot and weighed. It was expressed in g.

3.11.5 Grain yield (kg/plot)

After harvest of the crop, grain from each unit plot was dried and weighed. The result was expressed as kg/plot.

3.12 Data analysis

The data was analyzed by using the "Statistix 10" Software (Statistix R, 2013)

3.13 Data collection on Disease

3.13.1 Disease severity

Percentage of leaf area infection data was taken three times i.e., 75, 85 and 95 DAS .10 plants/plot were selected and data was taken from flag leaf and penultimate leaf.

3.13.2 Evaluation of leaf blight severity

Bipolaris Leaf Blight disease severity of flag leaf and penultimate leaf was counted three times in 10 day's interval. First severity data were collected at the first appearance of blight symptoms. The leaf blight severity was determined by following 0-7 scale of (Hetzler, 1992):

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

Disease severity and disease incidence were assessed by the following formula as mentioned by Mian, (1995):

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

$$\text{Disease incidence (\%)} = \frac{\text{No. of infected plants}}{\text{Total no. of plants in the plot}} \times 100$$

3.14 Seed Health Study after harvesting

Health status of the seeds of different treatments was done following ISTA rules (ISTA,1999). In this method three layers of blotter paper were soaked in sterilized water and placed at the bottom of the glass petridish. Then 25 seeds were set up on the blotting paper in each petridish maintaining equal distance and covered with lid. Total 400 seeds were used from each treatment and replication. Seeds thus plated were incubated at room temperature about 30°C for 7 days in Plant Pathology Laboratory of Hajee Mohammad Danesh Science and Technology University, Dinajpur. After 7 days of incubation the seeds were observed for the presence of seed-borne *Bipolaris sorokiniana* and other fungi under stereo binocular microscope. Germination percentage of the seeds was also recorded.

Chapter IV

Results

4.1 Effect of treatments on percentage of disease leaf area and disease severity of flag leaf

4.1.1 Effect of treatments on disease leaf area percentage of flag leaf recorded at different dates of data collection

Table 1. Effect of treatments on disease leaf area percentage of flag leaf

Treatment	Disease leaf area percentage of flag leaf		
	At 75 DAS	At 85 DAS	At 95 DAS
T_1	21.45 a	27.62 a	47.98 a
T_2	17.58 bc	25.30 b	43.92 b
T_3	18.48 b	23.75 b	47.06 ab
T_4	21.40 a	28.11 a	46.57 ab
T_5	16.13 c	24.97 b	48.02 a
SE±	0.95	1.04	1.64
LSD	2.09	2.28	3.58

T_1: 100% FRG recommended dose (control)

T_2: FRG recommended dose (100% urea+85% TSP +100% MoP) + ROOTOPEX

T_3: FRG recommended dose (100% urea+70% TSP +100% MoP) + ROOTOPEX

T_4: FRG recommended dose (100% urea+50% TSP +100% MoP) +ROOTOPEX

T_5: Farmer's practice (650g urea+ 550g TSP+ 450g MoP)

Different values of the effects of treatments on disease leaf area percentage of flag leaf at 75, 85 and 95 DAS were presented in Table 1. There was a variation of percentage disease leaf area was observed at 75 days after sowing of wheat. Here the table showed that the values was statistically significant among all the treatments. The highest percentage of disease leaf area at 75 DAS was recorded (21.45%) at T_1 which was also similar with T_4. And the lowest disease leaf area of flag leaf was recorded (16.13%) at T_5.

On the other hand at 85 DAS the highest disease leaf area percentage of flag leaf was recorded (28.11%) at T_4 and the lowest value (23.75%) was at T_3. In final observation at 95 DAS the highest percentage leaf area damage was found in T_5 having (41.02%) which was similar with T_1, T_3 and T_4. Having disease leaf are 47.98%, 47.06% and 46.57% respectively. Again the lowest disease leaf area was found in T_2 having (43.92%).

4.1.2 Effect of treatments on disease severity percentage of flag leaf at 75, 85 and 95 days after sowing.

Table 2. Effect of treatments on disease severity percentage of flag leaf

Treatment	Disease severity percentage of flag leaf		
	At 75 DAS	**At 85 DAS**	**At 95 DAS**
T_1	20.37 ns	30.54 a	48.51 ab
T_2	22.04	27.11 ab	43.69 ab
T_3	16.12	20.75 b	38.84 b
T_4	20.75	28.18 ab	44.87 ab
T_5	17.95	27.14 ab	43.69 ab
SE±	3.17	3.51	3.93
LSD	6.92	7.64	8.58

T_1: 100% FRG recommended dose (control)

T_2: FRG recommended dose (100% urea+85% TSP +100% MoP) + ROOTOPEX

T_3: FRG recommended dose (100% urea+70% TSP +100% MoP) + ROOTOPEX

T_4: FRG recommended dose (100% urea+50% TSP +100% MoP) +ROOTOPEX

T_5: Farmer's practice (650g urea+ 550g TSP+ 450g MoP)

Disease severity percentage of flag leaf was recorded at different dates of observation and the data were presented in table 2. From the table it was observed at 75 DAS the disease severity percentage showed not significantly varied among the treatment where the highest percentage of disease severity was found T_2 having (22.04%) and the lowest value found in T_3 having (16.12%)

At 85 and 95 DAS, it showed that there were statistically significant variation among the treatment. The highest percentage of disease severity found at 85 DAS at T_1 having (30.54%) which was similar to T_2, T_3 and T_4 . And the lowest value was noted (20.75%) at T_3. On the other hand at 95 DAS the highest percentage of disease severity was found at T_1 having 48.51 which was similar to T_2, T_4, and T_5 . And the lowest value was noted at T_3.

4.2 Effect of treatments on percentage of disease leaf area and disease severity of penultimate leaf

4.2.1 Effect of treatments on disease leaf area percentage of penultimate leaf recorded at different dates of data collection

Table 3. Effect of treatments on disease leaf area percentage of penultimate leaf

Treatment	Disease leaf area percentage of penultimate leaf		
	At 75 DAS	At 85 DAS	At 95 DAS
T_1	23.09 ns	38.99 a	55.20 ns
T_2	21.97	31.85 b	51.60
T_3	17.43	31.76 b	50.12
T_4	18.68	30.44 b	48.12
T_5	17.61	35.10 ab	52.12
SE±	3.09	3.15	3.19
LSD	6.69	6.88	6.95

T_1: 100% FRG recommended dose (control)

T_2: FRG recommended dose (100% urea+85% TSP +100% MoP) + ROOTOPEX

T_3: FRG recommended dose (100% urea+70% TSP +100% MoP) + ROOTOPEX

T_4: FRG recommended dose (100% urea+50% TSP +100% MoP) +ROOTOPEX

T_5: Farmer's practice (650g urea+ 550g TSP+ 450g MoP)

The effects of the treatments on the percentage of disease leaf area of the penultimate leaf at various data collecting dates were displayed in Table 3. There was a change in the penultimate leaf's percentage diseased leaf area after sowing of wheat. For both the first and third observations, this variation was not statistically significant. At 75 DAS, T_1 had the largest disease leaf area of penultimate leaf having (23.09%), whereas T_3 had the lowest value having (17.43%).

This table revealed that, only at 85 DAS the percentage of diseased leaf area of the penultimate leaf exhibit significant variation across treatments. T_1 had the highest percentage of damaged leaf area of penultimate leaf having (38.99%) which was similar with T_5 . And T_4 had the lowest percentage of disease leaf area having (30.44%).

At 95 DAS, the highest percentage of diseased leaf area of penultimate leaf was found at T_1 having (55.20%) and the lowest value noted at T_4 having (48.12%).

4.2.2 Effect of treatments on disease severity percentage of penultimate leaf at 75, 85 and 95 days after sowing.

Table 4. Effect of treatments on disease severity percentage of penultimate leaf

Treatment	Disease severity percentage of penultimate leaf		
	At 75 DAS	At 85 DAS	At 95 DAS
T_1	20.80 a	30.59 ns	56.78 ns
T_2	18.63 ab	29.26	54.59
T_3	15.18 b	26.76	54.32
T_4	16.65 ab	28.73	51.63
T_5	19.82 b	30.96	52.37
SE±	2.06	2.89	2.84
LSD	4.49	6.29	6.20

T_1: 100% FRG recommended dose (control)

T_2: FRG recommended dose (100% urea+85% TSP +100% MoP) + ROOTOPEX

T_3: FRG recommended dose (100% urea+70% TSP +100% MoP) + ROOTOPEX

T_4: FRG recommended dose (100% urea+50% TSP +100% MoP) +ROOTOPEX

T_5: Farmer’s practice (650g urea+ 550g TSP+ 450g MoP)

Table 4 displayed the effect of treatments on the percentage of disease severity of penultimate leaf at 75, 85 and 95 DAS after sowing wheat . The percentage of disease severity at 75 DAS only showed that it was statistically significant. On the other hand the variation of the percentage of disease severity of penultimate leaf was not statistically significant at 85 and 95 DAS. The highest percentage of disease severity of penultimate leaf was noted at 75 DAS having (20.80%) at T_1 which was similar with T_2 and T_4 having 18.63 and 16.65 respectively. And here the lowest value noted at T_3 having (15.18%).

At 85 DAS, the highest percentage of disease severity of penultimate leaf was reported (30.96%) at T_5 and the lowest value was noted at T_3 having (26.76%). Again at 95 DAS, the highest percentage of disease severity of penultimate leaf was reported (56.78%) at T_1 and the lowest value was noted at T_4 having (51.63%).

4.3 Effect of treatments on different growth parameter at different dates of data collection

4.3.1 Effect of treatments on plant height at different dates of data collection

Table 5. Effect of treatments on plant height (cm)

Treatment	Plant Height (cm)		
	At 35 DAS	At 55 DAS	At 95 DAS
T_1	44.40 ns	86.25 ns	99.25 ns
T_2	42.50	86.25	100.13
T_3	43.85	87.00	100.49
T_4	43.20	87.65	98.38
T_5	43.90	85.70	96.85
SE±	1.50	1.57	2.53
LSD	3.28	3.42	5.52

T_1: 100% FRG recommended dose (control)

T_2: FRG recommended dose (100% urea+85% TSP +100% MoP) + ROOTOPEX

T_3: FRG recommended dose (100% urea+70% TSP +100% MoP) + ROOTOPEX

T_4: FRG recommended dose (100% urea+50% TSP +100% MoP) +ROOTOPEX

T_5: Farmer's practice (650g urea+ 550g TSP+ 450g MoP)

Table 5 showed the effect of treatments on plant height (cm) at 35, 55, and 95 DAS. Plant height (cm) did not differ statistically significant among 35, 55 and 95 DAS. The highest plant height measured at T_1 having (44.40 cm) while the lowest plant height was measured at T_4 having 43.20 cm at 35 DAS. Once more at 55 DAS, the highest plant height measured was at T_3 having (87.00 cm) while the lowest value was noted 85.70 cm.

At 95 DAS,this table showed that the highest plant height was noted at T_3 having (100.49cm) and the lowest value noted at T_5 having (96.85cm)

4.3.2 Effect of treatments on total number of plants per meter square

Table 6. Effect of treatments on total number of plants per meter square

Treatment	Total number of plant/m^2
T_1	175.75 c
T_2	191.75 a
T_3	179.50 bc
T_4	181.75 bc
T_5	187.75 ab
SE±	4.26
LSD	9.29

T_1: 100% FRG recommended dose (control)

T_2: FRG recommended dose (100% urea+85% TSP +100% MoP) + ROOTOPEX

T_3: FRG recommended dose (100% urea+70% TSP +100% MoP) + ROOTOPEX

T_4: FRG recommended dose (100% urea+50% TSP +100% MoP) +ROOTOPEX

T_5: Farmer's practice (650g urea+ 550g TSP+ 450g MoP)

Table 6 represented the effect of treatments on total number of plants per meter square. There was a statistically significant variation among all the treatments in the total number of plants per meter square.

In this table here T_2 had the greatest number of plants having 191.75 while T_1 had the fewest number of plant per meter square having 175.75 .

4.3.3 Effect of treatments on leaf length and leaf breadth (cm) at 55 DAS of data collection

Table 7. Effect of treatments on leaf length and leaf breadth (cm)

Treatment	**Leaf length (cm)**	**Leaf breadth(cm)**
	55 DAS	**55 DAS**
T_1	29.04 ns	1.67 ns
T_2	28.03	2.05
T_3	28.38	1.81
T_4	28.06	2.00
T_4	28.26	1.80
SE±	1.12	0.21
LSD	2.45	0.47

T_1: 100% FRG recommended dose (control)

T_2: FRG recommended dose (100% urea+85% TSP +100% MoP) + ROOTOPEX

T_3: FRG recommended dose (100% urea+70% TSP +100% MoP) + ROOTOPEX

T_4: FRG recommended dose (100% urea+50% TSP +100% MoP) +ROOTOPEX

T_5: Farmer's practice (650g urea+ 550g TSP+ 450g MoP)

Table 7 showed the effect of treatments on leaf length and breadth (cm) after 55 days of data collection. It expressed a variety of values but none of them were statistically significant. The longest leaf length was seen at T_1 having (29.04cm) and the shortest leaf length at T_2 having (28.03cm). On the other hand the longest breadth was measured at T_2 having (2.05cm) and the shortest breadth measured at T_4 having (1.80%).

4.3.4 Effect of treatments on spike length (cm) at 95 DAS

Table 8. Effect of treatments on spike length (cm)

Treatment	Spike length (cm)
	95 DAS
T_1	13.65 a
T_2	13.35 ab
T_3	13.35 ab
T_4	12.20 b
T_5	12.45 ab
SE±	0.65
LSD	1.43

T_1: 100% FRG recommended dose (control)

T_2: FRG recommended dose (100% urea+85% TSP +100% MoP) + ROOTOPEX

T_3: FRG recommended dose (100% urea+70% TSP +100% MoP) + ROOTOPEX

T_4: FRG recommended dose (100% urea+50% TSP +100% MoP) +ROOTOPEX

T_5: Farmer's practice (650g urea+ 550g TSP+ 450g MoP)

Table 8 showed that spike length (cm) was differed across treatments when data was obtained at 95 DAS. The spike length measurements in (cm) were statistically significant among all the treatments. At 95 DAS, the highest spike length was measured to be 13.65 cm at T_1, while the minimum spike length was noted 12.20 cm at T_4.

4.3.5 Effect of treatments on number of spikelets per panicle of wheat

Table 9. Effect of treatments on number of spikelets per panicle

Treatment	Number of spikelets/panicle
T_1	17.20 ns
T_2	17.62
T_3	18.47
T_4	17.40
T_5	17.05
SE±	1.38
LSD	3.02

T_1: 100% FRG recommended dose (control)
T_2: FRG recommended dose (100% urea+85% TSP +100% MoP) + ROOTOPEX
T_3: FRG recommended dose (100% urea+70% TSP +100% MoP) + ROOTOPEX
T_4: FRG recommended dose (100% urea+50% TSP +100% MoP) +ROOTOPEX
T_5: Farmer’s practice (650g urea+ 550g TSP+ 450g MoP)

Table 9 represented the proportion of number of spikelet per panicle of wheat for all treatments. And this table showed that the values were not significantly significant among all the treatments. In this table, T_3 had the greatest number of spikelets per panicle having (18.47%), whereas T_5 had the lowest number of spikelets per panicle having (17.05%).

4.3.6 Effect of treatments on total number of grains per spike after harvesting

Table 10. Effect of treatments on total number of grains per spike

Treatment	Total number of grains /spike
T_1	38.50 b
T_2	43.50 a
T_3	40.00 ab
T_4	41.25 ab
T_5	43.75 a
SE±	2.18
LSD	4.77

T_1: 100% FRG recommended dose (control)

T_2: FRG recommended dose (100% urea+85% TSP +100% MoP) + ROOTOPEX

T_3: FRG recommended dose (100% urea+70% TSP +100% MoP) + ROOTOPEX

T_4: FRG recommended dose (100% urea+50% TSP +100% MoP) +ROOTOPEX

T_5: Farmer's practice (650g urea+ 550g TSP+ 450g MoP)

Table 10 demonstrated the effect of treatments on total number of grains per spike. From this table it was noted that there were statistically significant variation in the proportion of total grains per spike among all the treatment. In terms of percentage of total grains/spike, the highest number of grains per spike was found at T_5 having (43.75) which was also similar with T_2 having (43.50) . And the lowest value of total grains per spike was found at T_1 having (38.50).

4.4 Effect of treatments on seeds after harvesting

4.4.1. Effect of treatments on percentage of normal and undersized seeds after harvesting

Table 11. Effect of treatments on percentage of normal and undersized seeds

Treatment	Percentage of Normal seeds	Percentage of Undersized seeds
T_1	65.00 b	20.50 a
T_2	73.75 a	14.25 b
T_3	72.25 a	15.50 b
T_4	72.00 a	15.50 b
T_5	64.50 b	18.75 a
SE±	2.13	1.37
LSD	4.64	2.98

T_1: 100% FRG recommended dose (control)

T_2: FRG recommended dose (100% urea+85% TSP +100% MoP) + ROOTOPEX

T_3: FRG recommended dose (100% urea+70% TSP +100% MoP) + ROOTOPEX

T_4: FRG recommended dose (100% urea+50% TSP +100% MoP) +ROOTOPEX

T_5: Farmer’s practice (650g urea+ 550g TSP+ 450g MoP)

The impact of treatments on the percentage of normal seed and undersized seed was displayed in Table 11. These two categories was represented the division of seeds after harvesting of wheat. It was observed from this table that the percentage of normal and undersized seed were statisticaly significant. Here T_2 had the largest percentage of normal seeds having (73.75%) which was also similar with T_3 and T_4 having 72.25% and 72.00% respectively. And T_5 had the lowest percentage of normal seed having (64.50%).

When it comes to undersized seed, T_1 had the highest percentage (20.50%) which was similar with T_5 having 18.75%. And here T_2 had the lowest proportion of undersized seed having (14.25%).

4.4.2 Effect of treatments on percentage of broken and black pointed seeds

Table 12. Effect of treatments on percentage of broken and black pointed seeds

Treatments	Percentage Broken seed	Percentage of Black pointed seed
T_1	8.25 ns	6.25 ab
T_2	7.00	5.00 b
T_3	6.50	5.75 b
T_4	6.75	5.75 b
T_5	8.50	8.25 a
SE±	1.08	0.93
LSD	2.36	2.03

T_1: 100% FRG recommended dose (control)
T_2: FRG recommended dose (100% urea+85% TSP +100% MoP) + ROOTOPEX
T_3: FRG recommended dose (100% urea+70% TSP +100% MoP) + ROOTOPEX
T_4: FRG recommended dose (100% urea+50% TSP +100% MoP) +ROOTOPEX
T_5: Farmer's practice (650g urea+ 550g TSP+ 450g MoP)

Effect of treatments on percentage of broken and black pointed seeds was represented here in table 13. In the case of broken seed, here the table showed that the values were statistically non significant among all the treatment. The maximum percentage of broken seed was found at T_5 having (8.25%) and the minimum values noted at T_3 having (6.50%).

Again in case of black pointed seed, here it noted that the values were statistically significant among all the treatments. The maximum percentage of black pointed seed was found at T_5 having (8.25%) and the minimum values noted at T_2 having (5.00%).

4.5 Effect of treatment on yield after harvesting

Table 13. Effect of treatment on total yield (kg/plot)

Treatment	Total yield (kg/plot)
T_1	12.02 b
T_2	13.32 a
T_3	13.30 a
T_4	12.59 ab
T_5	12.25 ab
SE±	0.55
LSD	1.21

T_1: 100% FRG recommended dose (control)

T_2: FRG recommended dose (100% urea+85% TSP +100% MoP) + ROOTOPEX

T_3: FRG recommended dose (100% urea+70% TSP +100% MoP) + ROOTOPEX

T_4: FRG recommended dose (100% urea+50% TSP +100% MoP) +ROOTOPEX

T_5: Farmer's practice (650g urea+ 550g TSP+ 450g MoP)

The effect of treatments on total yield (kg/plot) was represented at table 13. In this table it showed that the total yield (kg/plot) was statistically significant among all the treatment. Here T_2 had the highest amount of yield having (13.32 kg/plot) which was similar with T_3 having (13.30kg/plot). And T_1 had the lowest amount of yield having (12.02 kg/plot).

4.6 Effect of treatments on thousand grain weight(g) of wheat

Table 14. Effect of treatments on thousand grain weight(g)

Treatment	Thousand grain weight (g)
T_1	52.53 ab
T_2	54.54 a
T_3	53.17 ab
T_4	51.45 ab
T_5	50.95 b
SE±	1.17
LSD	2.55

T_1: 100% FRG recommended dose (control)

T_2: FRG recommended dose (100% urea+85% TSP +100% MoP) + ROOTOPEX

T_3: FRG recommended dose (100% urea+70% TSP +100% MoP) + ROOTOPEX

T_4: FRG recommended dose (100% urea+50% TSP +100% MoP) +ROOTOPEX

T_5: Farmer's practice (650g urea+ 550g TSP+ 450g MoP)

Table 14 represented here the effect of treatments on thousand grain weight (g) of wheat. This table showed that there was statistically significant variation in thousand grain weight (g) among all of the treatments. At T_2, the maximum weight was found having (54.54g) which was similar with T_1, T_3 and T_4 having 52.53g, 53.17g and 51.45g respectively. The minimum weight(g) of thousand grain was noted at T_5 having 50.95g.

4.7 Effect of treatments on straw (g/plot) after harvesting

Table 15. Effect of treatments on straw (g/plot)

Treatment	straw (g/plot)
T_1	23.05 bc
T_2	28.40 a
T_3	25.40 b
T_4	24.52 bc
T_5	22.10 c
SE±	1.18
LSD	2.58

T_1: 100% FRG recommended dose (control)

T_2: FRG recommended dose (100% urea+85% TSP +100% MoP) + ROOTOPEX

T_3: FRG recommended dose (100% urea+70% TSP +100% MoP) + ROOTOPEX

T_4: FRG recommended dose (100% urea+50% TSP +100% MoP) +ROOTOPEX

T_5: Farmer's practice (650g urea+ 550g TSP+ 450g MoP)

The effect of the treatments on straw (g/plot) were shown in table 15. There was statistically significant difference in the effect of treatments on total straw (g/plot). Here T_2 had the highest amount of straw (28.40g/plot) while T_5 had the lowest amount of straw having (22.10g/plot).

4.8 Effect of treatments on seed health test

4.8.1 Effect of treatments on percentage of total seed germination and dead seed.

Table 16. Effect of treatments on percentage of total seed germination and dead seed.

Treatment	Percentage of total seed germination	Percentage of dead seed
T_1	91.00 ab	8.75 ab
T_2	92.00 a	8.00 b
T_3	89.75 ab	10.25 ab
T_4	89.00 b	11.00 a
T_5	91.25 ab	9.50 ab
SE±	1.06	1.06
LSD	2.31	2.31

T_1: 100% FRG recommended dose (control)

T_2: FRG recommended dose (100% urea+85% TSP +100% MoP) + ROOTOPEX

T_3: FRG recommended dose (100% urea+70% TSP +100% MoP) + ROOTOPEX

T_4: FRG recommended dose (100% urea+50% TSP +100% MoP) +ROOTOPEX

T_5: Farmer's practice (650g urea+ 550g TSP+ 450g MoP)

Effect of treatments on percentage of total seed germination and dead seed were presented at table 16. There was statistically significant variation among the all treatment. The result revealed that maximum number of percentage of total seed germination obtained at T_2 having (92%) which was similar to T_1, T_3 and T_5 having 91.00%, 89.75% and 91.25% respectively. And the minimum number of percentage of seed germination at T_4 having (89%).

Here the table showed that the maximum number of percentage of dead seed was found at T_4 having (11%) which was similar with T_1, T_3 and T_5 having 8.75%, 10.25% and 9.50% respectively. And minimum number of percentage of dead seed was found at T_2 having (8.00%) .

4.8.2 Effect of treatments on percentage of normal and abnormal seedlings.

Table 17. Effect of treatments on percentage of normal and abnormal seedlings.

Treatment	Percentage of normal seedlings	Percentage abnormal seedlings
T_1	87.75 a	4.00 ns
T_2	88.25 a	3.75
T_3	85.25 b	4.75
T_4	83.75 b	5.25
T_5	86.25 ab	4.25
SE±	1.18	1.10
LSD	2.58	2.42

T_1: 100% FRG recommended dose (control)

T_2: FRG recommended dose (100% urea+85% TSP +100% MoP) + ROOTOPEX

T_3: FRG recommended dose (100% urea+70% TSP +100% MoP) + ROOTOPEX

T_4: FRG recommended dose (100% urea+50% TSP +100% MoP) +ROOTOPEX

T_5: Farmer's practice (650g urea+ 550g TSP+ 450g MoP)

Table 17 represented here the effect of treatments on percentage of normal and abnormal seedling. This table showed that There was statistically significant variation among the all treatment. The highest number of percentage of normal seedling was found at T_2 having (88.25%) which was similar to T_1 and T_5 having 87.75% and 86.25 %. On the other hand the lowest number of percentage of normal seedling at T_4 having (83.75%).

Maximum number of percentage of abnormal seedling was obtained at T_4 having (5.25%) and minimum percentage was noted at T_2 having (3.75%).

4.9 Effect of treatments on percentage of pathogenic fungi associated with wheat seed

Table 18. Effect of treatments on pathogenic fungi associated with seeds

Treatment	Percentage of pathogen associated with wheat seed				
	Bipolaris sp.	*Alrtenaria* sp.	*Curvularia* sp.	*Fusarium* sp.	*Aspergillus* sp.
T_1	8.75 b	5.00 a	4.25 b	7.50 b	5.00 b
T_2	8.00 b	3.25 ab	5.75 ab	7.25 b	5.00 b
T_3	11.50 a	6.50 a	5.00 b	9.50 a	5.50 ab
T_4	11.50 a	5.75 a	7.50 a	7.50 b	6.25 ab
T_5	12.25 a	5.75 a	6.25 ab	8.25 ab	7.00 a
SE±	1.06	0.91	0.98	0.89	0.71
LSD	2.31	1.98	2.13	1.95	1.56

T_1: 100% FRG recommended dose (control)

T_2: FRG recommended dose (100% urea+85% TSP +100% MoP) + ROOTOPEX

T_3: FRG recommended dose (100% urea+70% TSP +100% MoP) + ROOTOPEX

T_4: FRG recommended dose (100% urea+50% TSP +100% MoP) +ROOTOPEX

T_5: Farmer's practice (650g urea+ 550g TSP+ 450g MoP)

Table 18 represented here the effect of treatments on pathogenic fungi associated with wheat seed. This table showed that *Bipolaris* sp., *Alrtenaria* sp. , *Curvularia* sp. , *Fusarium* sp. and *Aspergillus* sp. were the pathogen which associated with wheat seed and there were statistically significant variation found among all the treatment. The maximum percentage of *Bipolaris* sp. was recorded at T_5 having (12.25%) which was similar with T_3 and T_4 and both having 11.50%. And the minimum percentage of *Bipolaris* sp. was noted at T_2 having 8.00% which were associated with wheat seed. In case of percentage of *Alternaria* sp., the maximum value was found at T_3 having (6.50%) which was similar with T_4 and T_5 and both having 5.75%. The minimum percentage of *Alternaria* sp. was noted at T_2 having 3.25%. Once more in case of *Curvularia* sp., the maximum percentage was found at T_4 having 7.50% which was similar with T_2 and T_5 having 5.75% and 6.25%. The minimum percentage of *Curvularia* sp. was noted at T_3 having 5.00%. Again the maximum percentage of *Fusarium* sp. was recorded at T_3 having 9.50% which was similar with T_5 having 8.25%. The minimum percentage of *Fusarium* sp. was noted at T_2 having 7.25%. In case of *Aspergillus* sp. ,the maximum percentage recorded at T_5 having 7%.

4.10 Effect of treatments on number of healthy grains per spike

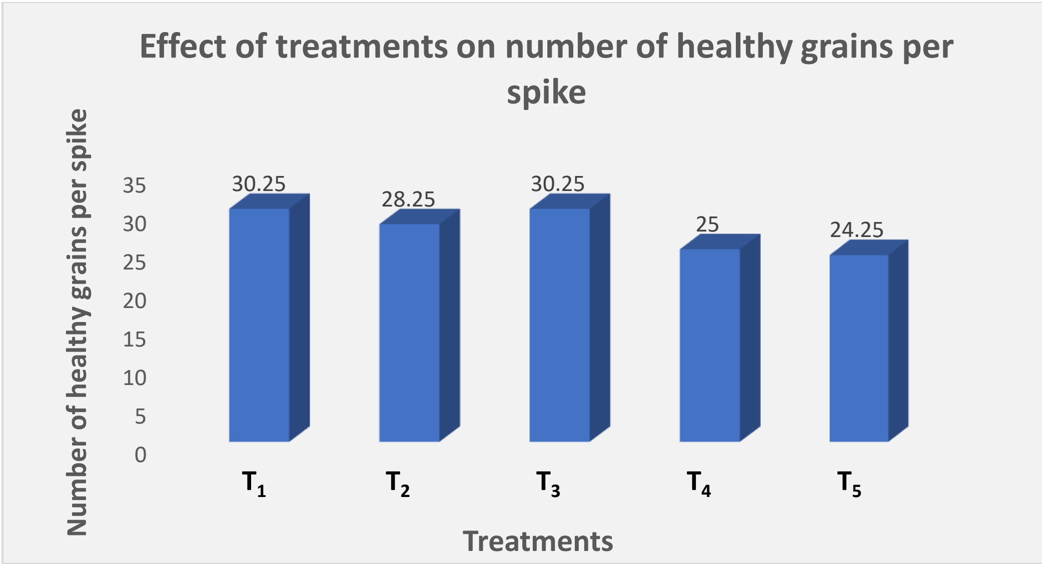

Fig. 1: Effect of treatments on Number of healthy grains per spike

T_1: 100% FRG recommended dose (control)

T_2: FRG recommended dose (100% urea+85% TSP +100% MoP) + ROOTOPEX

T_3: FRG recommended dose (100% urea+70% TSP +100% MoP) + ROOTOPEX

T_4: FRG recommended dose (100% urea+50% TSP +100% MoP) +ROOTOPEX

T_5: Farmer's practice (650g urea+ 550g TSP+ 450g MoP)

Total number of healthy grains per spike was recorded after harvesting and average number of healthy grains per spike was calculated and presented in figure 1. From the figure it was observed that maximum number of healthy grains per spike was recorded at T_1 and T_3 having both 30.25% and minimum number of healthy grains per spike was recorded at T_5 having 24.25%

4.11 Effect of treatments on number of undersized grains per spike

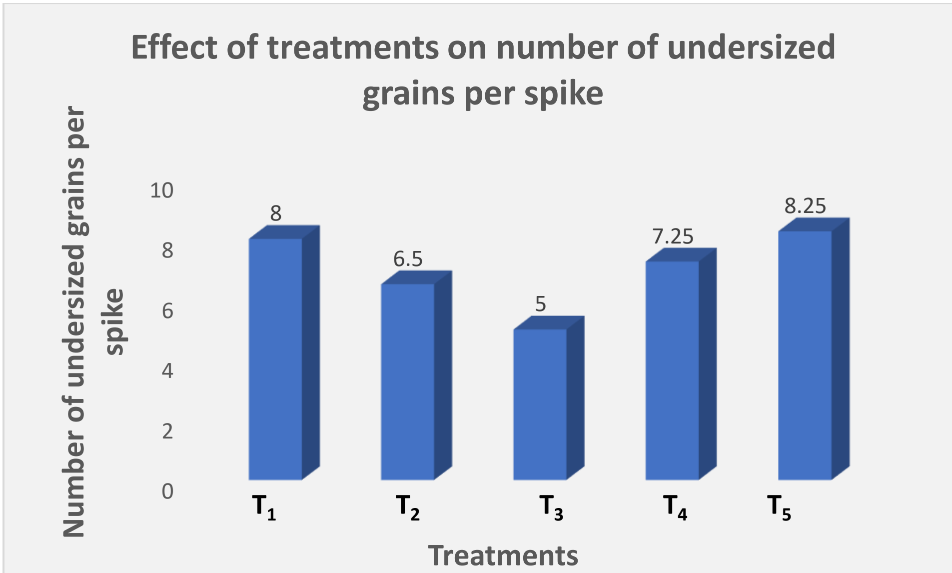

Fig.2: Effect of treatments on number of undersized grains per spike

T_1: 100% FRG recommended dose (control)

T_2: FRG recommended dose (100% urea+85% TSP +100% MoP) + ROOTOPEX

T_3: FRG recommended dose (100% urea+70% TSP +100% MoP) + ROOTOPEX

T_4: FRG recommended dose (100% urea+50% TSP +100% MoP) +ROOTOPEX

T_5: Farmer's practice (650g urea+ 550g TSP+ 450g MoP)

Total number of undersized grains per spike was recorded after harvesting and average number of undersized grains per spike was calculated and presented in figure 2. From the figure it was observed that maximum number of undersized grains per spike recorded at T_5 having 8.25% and minimum number of undersized grains per spike was recorded at T_3 having 5%.

4.12 Effect of treatments on number of black pointed grains per spike

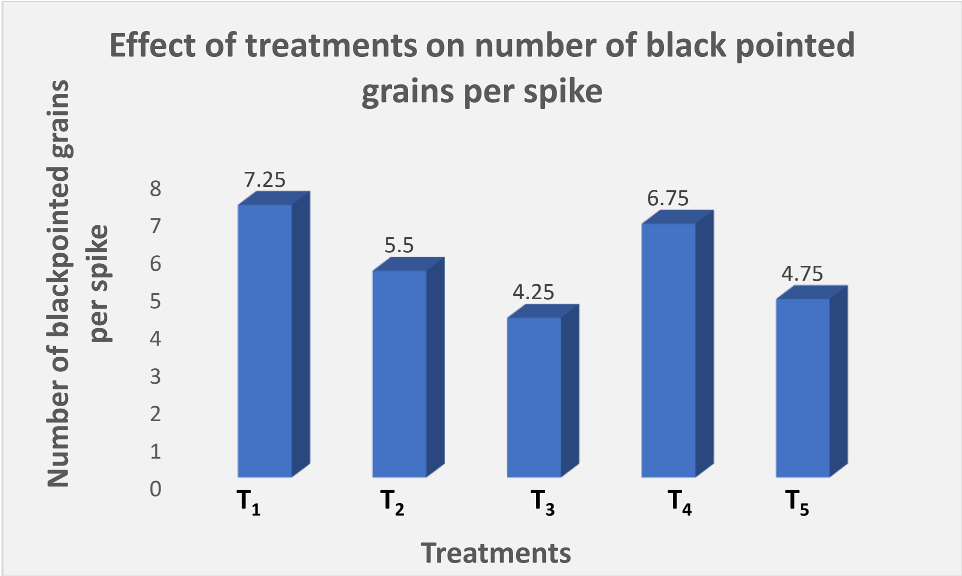

Fig. 3: Effect of treatments on number of black pointed grains per spike

T_1: 100% FRG recommended dose (control)

T_2: FRG recommended dose (100% urea+85% TSP +100% MoP) + ROOTOPEX

T_3: FRG recommended dose (100% urea+70% TSP +100% MoP) + ROOTOPEX

T_4: FRG recommended dose (100% urea+50% TSP +100% MoP) +ROOTOPEX

T_5: Farmer's practice (650g urea+ 550g TSP+ 450g MoP)

Total number of black pointed grains per spike was recorded after harvesting and average number of black pointed grains per spike was calculated and presented in figure 3. From the figure it was observed that maximum number of black pointed grains per spike was recorded at T_1 having 7.25% and minimum number of black pointed grains per spike was recorded at T_3 having 4.25%.

Discussion

Bipolaris sorokiniana (Sacc.) the causative agent of leaf blight of wheat, is one of the most serious diseases imposing wheat productivity constraints in South Asian nations such as Bangladesh, India, and Nepal. Wheat leaf blight severity varied greatly depending on the variety, when it was sown and how disease management techniques were used etc. In this study, the effect of leaf blight disease on wheat, the effect of different treatments and different agronomic parameters were discussed here.

For controlling leaf blight of wheat and increasing yield in this experiment we increased nutrient value through applying PGR with fertilizers. Here the five treatments were used in this experiment named as, T_1:100% FRG recommended dose (control), T_2: FRG recommended dose (100% urea+85% TSP +100% MoP) + ROOTOPEX, T_3: FRG recommended dose (100% urea+70% TSP +100% MoP) + ROOTOPEX, T_4: FRG recommended dose (100% urea+50% TSP +100% MoP) +ROOTOPEX and T_5: Farmers practice (650g urea+ 550g TSP+ 450g MoP) . According to this experiment the plot where PGR were used that showed positive feedback than the unsprayed plots.

Before considering a chemical treatment, cultural approaches can help manage crop development as well as protect it from pests and diseases. From this study it was found that plant growth regulator (PGR) had positive response in reducing the leaf blight disease caused by *Bipolaris sorokiniana*. Similar findings was conducted by Morh et al., (1987), Krupinsky and Tanaka, (2001), Duveiller et al., (2003) who found the positive response of PGR against leaf blight of wheat by *Bipolaris sorokiniana*. In their opinion numerous research conducted in different areas indicate that boosting nutrients might be control wheat foliar blights. The findings of the present study had the similarity with the report of Zahid G, Iftikhar S, Shimira F, Ahmad HM and Aka Kaçar Y who stated that PGRs are used extensively in wheat production, primarily for seed treatment, foliar spraying, and soil applications. There were another similaries with Gao YT, Tian XJ and Wang WD *et al.* (2010) who demonstrated that PGRs can control wheat's endogenous hormone levels, improving the grain's susceptibility to pests, diseases, drought and salt alkalinity. From this similarities it showed that PGR has great response against diseases.

But there were also dissimilarities with findings of some experiment which were conducted by Uddin et al. (2009) who stated that PGRs are substances that change plant growth by boosting branching, reducing shoot growth, increasing return bloom, eliminating surplus fruit or changing fruit maturity. According to his statement PGR only plays the role to promote the growth of plant not for controlling diseases.

The use of growth regulators is a promising and fast increasing topic in modern agriculture. Korshunov et al. (2015) claimed that one method that improves the effectiveness of utilizing plants' genetic potential and a strong agricultural heritage is the application of growth regulators. Here this experiment indicated that those treatment which belong to plant growth regulators were more effective to control diseases and increasing the yields of wheat production.

In case of plant height after 95 DAS, the effect of treatments showed non significant variation among them. Even no significant result observed in leaf length and leaf breadth of wheat crops among all the treatments. In case of percent diseased leaf area of flag leaf, the treatments which related to plant growth regulator (Rootopex) showed less percent of diseased leaf area of flag leaf after 95 DAS. The highest percentage flag leaf area damage was found in T_5 (Farmers practice) having (41.02%) . On the other hand percent diseased leaf area of penultimate leaf, here also the treatment which related to plant growth regulator showed less percent of diseased leaf area of penultimate leaf after 95 DAS. The highest percentage of diseased leaf area of penultimate leaf was found at T_1 (100% FRG recommended dose (control) having (55.20%).

In case of disease severity, it was found that the treatment treated plant showed less disease severity than the untreated plant. The highest percent of disease severity of flag leaf recorded at T_1 (100% FRG recommended dose (control) having 48.51%. Again in case of penultimate leaf the highest percent of disease severity recorded at T_1 having 55.20%. So in this experiment PGR included treatment showed less percent of disease severity among all the treatments.

In case of total number of grains per spike, the highest number of grains was found in those plots where the treatment was added to plant growth regulator. Y.X. Guo, J.T. Wang, W.H. Liu *et al* (2010) stated that PGRs have the potential to impact various aspects of plant life, including root division, growth and differentiation, germination, blooming, fruiting, and even plant gender. In case of healthy grains per spike, clearly treatments associated with Rootopex showed the better result and the less amount of unhealthy grains were found.

When it comes to yield, the highest amount of yield recorded at T_2 (FRG recommended dose (100% urea+85% TSP +100% MoP) + ROOTOPEX, having 12kg/plot. Effect of treatment on yield were not showed any significant variation among the treatments which related to rootopex. Similar finding by Bakhoum GS, Tawfik MM, Kabesh MO and Sadak MS who claimed that PGRs have the following primary effects on wheat: PGRs can increase the development of wheat roots, as well as the plant's ability to absorb nutrients and use water. This can lead to the growth of stems, leaves, and roots.

In case of heathy, undersized, broken/default and black pointed seeds, the best result showed at the treatments which mixed with the plant growth regulator. There were significant variation among all the treatments. When it comes to seed health test ,the treatment mixed with Rootopex showed the highest percentage of seed germination .

From the overall studies it may be said that the treatments which mixed with PGR (Rootopex) showed the positive response against the effect of treatment on leaf blight disease severity and increased the yield. It also showed positive feedback against other agronomical parameter.

SUMMARY AND CONCLUSION

The experiment was conducted in the experimental field of the Agricultural Research Station (BARI), Dinajpur to find out how a plant growth regulator react on the Bipolaris leaf blight disease and the productivity of wheat. The experiment was conducted in the research field of BARI, Dinajpur following the Randomized Complete Block Design (RCBD). In the experiment field, the plot size was 2m × 4m. The variety of BARI Gom 33 was used in this experiment. A combination of plant growth regulator (Rootopex) was applied together with Urea, TSP and MoP in this experiment. The treatments used in the experiment were T_1:100% FRG recommended dose (control), T_2: FRG recommended dose (100% urea+85% TSP +100% MoP) + ROOTOPEX, T_3: FRG recommended dose (100% urea+ 70% TSP +100% MoP) + ROOTOPEX, T_4: FRG recommended dose (100% urea+50% TSP +100% MoP) +ROOTOPEX and T_5: Farmers practice (650g urea+ 550g TSP+ 450g MoP). Weeding and irrigation were also conducted as an intercultural operation. For conducting the experiment several parameters were used to collect data such as plant height, leaf length and breadth, spike length, percentage of disease leaf area and disease severity of flag leaf and penultimate leaf, total number of grains per spike, number of healthy, undersized and black pointed grains per spike, total yield and straw, thousand grain weight etc. After collecting the seeds, seed health test also were performed to determine the seed borne fungi associated with wheat seed. In this study, the recorded data were manually determined and the "Statistix 10" program was used to perform the statistical analysis.

Following data analysis, the data table displayed the outcome about the Bipolaris leaf blight of wheat. The result of this experiment showed that the combination of plant growth regulator (Rootopex) with fertilizer gave the positive response towards reducing the disease and increasing the yield of wheat. Though significant variation was not found in different parameter but in case of percentage of disease leaf area and severity, it showed significant variation among all the treatments. The highest percentage of disease leaf area and severity were found at those plots where Rootopex were not applied. In this experiment the lowest percentage of disease leaf area of flag leaf was recorded at T_2 having 43.92% and penultimate leaf was recorded at T_4 having 48.12% in the plots where Rootopex was applied. Again the lowest percentage of disease severity of flag leaf recorded at T_3 having 38.84% and penultimate leaf was recorded at T_4 having 51.63% in the plots where Rootopex was applied. The number of total healthy grains per spike and highest yield was noticeable where Rootopex was applied. In case seed health test the seeds from the plots where Rootopex were applied showed better performance. The highest percentage of total seed germination recorded at T_2 having 92%. Numerous fungus both pathogenic and non-pathogenic were discovered from the seed that was gathered from experiment plot. The following fungal pathogens *Bipolaris* sp., *Fusarium* sp., *Alternaria* sp. , *Curvularia* sp. and *Aspergillus* sp.were found with wheat seeds. The maximum number of pathogens recorded at T_5 where Rootopex were not applied.

Bipolaris sorokiniana caused leaf blight disease has become a major threat for wheat cultivation in Bangladesh in recent years. The severity of leaf blight has caused significant economic losses in wheat production and impacting the livelihood of millions of small-scale farmers. So from the findings of the present experiment it maybe concluded that combination of plant growth regulators with fertilizers can be helpful in reducing small percentage of leaf blight diseases and increase wheat yield. Therefore, when compared to the other treatments, the administration of Rootopex with fertilizer performed best in terms of growth characteristics, agronomic features, major disease incidence and severity in field conditions.

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