EFFECT OF SILICON (SiO_2) TO CONTROL *BIPOLARIS* LEAF BLIGHT AND TO IMPROVE SEED HEALTH STATUS OF WHEAT

A THESIS
BY

APURBA ROY

Student ID: 1601138

Thesis Semester: July-December, 2023

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IN

PLANT PATHOLOGY

DEPARTMENT OF PLANT PATHOLOGY

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY,

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DECEMBER, 2023

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DECEMBER, 2023

Dedicated to

My Mother

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ABSTRACT

The experiment was conducted in the research field of Hajee Mohammad Danesh Science and Technology University, Dinajpur from December 2022 to April 2023 to evaluate the effectiveness of various doses of silicon dioxide (SiO_2) as treatment to control leaf blight (*Bipolaris sorokiniana*) and to improve seed health status of wheat. In this experiment, three treatments were studied, T_1 = Silicon dioxide @60 kg ha^{-1}, T_2 = Silicon dioxide @120 kg ha^{-1}, T_3= Silicon dioxide @180 kg ha^{-1}. Two varieties were used, V_1= BWMRI Gom-1 and V_2= BWMRI Gom-2 within three replications and the experiment was set up as Randomized Complete Block Design (RCBD). *Bipolaris* leaf blight severity, seed health (seed number associated with pathogens and percent germination), plant height, spike length, thousands seed weight, biological yield, yield index and yield were significantly varied with different treatments. Minimum disease severity was recorded from Silicon dioxide @60 kg ha^{-1} on flag leaves at 67 DAS (2.3%), 72 DAS (6.44%), 77 DAS (6.77%), 82 DAS (8.35%) also on flag-1 leaves at 67 DAS (1.54%), 72 DAS (3.31%), 77 DAS (5.97%) and 82 DAS (11.12%). Minimum disease severity was recorded in BWMRI Gom-1 on flag leaf at 67 DAS (1.90%), 72 DAS (4.55%), 77 DAS (5.69%), 82 DAS (9.01%) and also on flag-1 leaves at 67 DAS (0.67%), 72 DAS (2.15%), 77 DAS (5.68%) and 82 DAS (10.19%). As a treatment variety interaction, the lowest disease severity on flag leaf was recorded from BWMRI Gom-1 with silicon dioxide @60 kg ha^{-1} interaction at 67 DAS (1.39%), 77 DAS (5.12%), 82 DAS (7.03%) and from BWMRI Gom-1 with Silicon dioxide @120 kg ha^{-1} interaction at 72 DAS (3.80%). Also the lowest disease severity on flag-1 leaves was recorded from BWMRI Gom-1 with Silicon dioxide @60 kg ha^{-1} at 67 DAS (0.0%), 72 DAS (1.11%), 77 DAS (3.72%) and 82 DAS (5.92%). As a treatment, minimum seed number was affected with *Bipolaris sorokiniana* was recorded from Silicon dioxide @60 kg ha^{-1} (10.13%). As a variety, minimum seed number was affected with *Bipolaris sorokiniana* was recorded from BWMRI Gom-1 (10.92%). Treatment variety interaction of BWMRI Gom-1 with Silicon dioxide @60 kg ha^{-1} showed minimum (8.18%) seed number was affected with *Bipolaris sorokiniana*. Highest grain yield (4.72 t ha^{-1}) was obtained from silicon dioxide @60 kg ha^{-1}. Maximum grain yield (4.36 t ha^{-1}) was produced from BWMRI Gom-1. The highest grain yield (4.76 t ha^{-1}) was obtained from the interaction of BWMRI Gom-1 with Silicon dioxide @60 kg ha^{-1}. Finally, the research study concluded that using of BWMRI Gom-1 with the application of Silicon dioxide @60 kg ha^{-1} can be used effectively with lowest leaf blight disease infestation with better yield.

Keywords: Silicon dioxide, *Bipolaris* leaf blight, Flag leaf, Flag-1 leaf, Seed health, Yield

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LIST OF ABBREVIATIONS

AEZ	: Argo Ecological Zone
CV	: Co-efficient of Variation
DAS	: Days After Sowing
DI	: Disease Incidence
DS	: Disease severity
LSD	: Least Significance Difference
PLP	: Plant Pathology
RCBD	: Randomized Complete Block Design
SRDI	: Soil Resource Development Institute

CHAPTER I

INTRODUCTION

The wheat crop is a member of the Poaceae family and belongs to the genus *Triticum*, scientifically it is named as *Triticum aestivum. Triticum aestivum L*., also known as wheat is a grass that is extensively grown for its grain or seed. It is a staple food in many parts of the world and a great source of plant protein for people's diets (James and Mauseth, 2018). Millions of people worldwide rely on wheat as a staple food. A staple food and a significant commodity in the global grain market is wheat grain. Wheat is one of the most produced valuable cereal crops in all over the world. Due to high nutritive value, wheat grains are eaten in various forms across cultures and continents (Acharya *et al*., 2011). Wheat is the second most produced cereal for human consumption and the third most produced cereal globally, behind rice and corn (maize) (World Economic Forum, 2022). Wheat production exceeded 734 million tons in 2018 from 214 million ha of land (FAO, 2021).

China, India, Russia, USA, and France were the largest producers of wheat in the world in 2018, accounting for more than 50% of the world's production (FAO, 2021). One of the earliest grains that humans domesticated was wheat, and by 5000 BC, bread wheat was reportedly being grown in the Nile Valley (Shewry, 2009). While rice has been more significant in East Asia, it is thought that wheat has played a major role in the civilizations of West Asia and Europe (Avraham and Moshe, 2022).

Despite being one of the oldest cereal crops, it was first brought to Bengal in 1930–1931; nevertheless, it wasn't until 1942–1943 that its significance as a food crop became apparent (Banglapedia, 2021). However, in Bangladesh, it is the second most important cereal crop, right after rice.

There are many constraints responsible for lower yield of wheat in Bangladesh, among which use of unhealthy or diseased seeds are one of the major constraints (Monjil and Hossain, 2003, Panna *et al*., 2009). Numerous biological factors restrict wheat production, with diseases being a major global constraint on wheat production. Over 200 wheat diseases have been identified to date, but only 50 of those diseases are widely distributed and cause economic loss (Wiese, 1987; Al-Sadi, 2016; Jarroudi *et al*., 2017; Lalic *et al*., 2017; Riaz *et al*., 2017; Sharma *et al*., 2017). Diseases result in 20% yield of wheat to be lost annually. According to 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). Rusts, spot blotch, common root rot, smut, tan spot, Septoria blotch, powdery mildew, *fusarium* head blight, blast, and a number

of bacterial, nematode, and viral diseases are some of the major wheat diseases. They cause the afflicted plants to die off or produce less. *Bipolaris* leaf blight caused by *Bipolaris sorokiniana* is a major biotic constrain affecting wheat production in Bangladesh (Ahmed and Meisner, 1996, Monjil *et al*., 2005). In farmer's field, the average yield loss of wheat due to leaf blight disease was estimated upto 10-21% and it could reach to 100% in case of severe infection (Malaker *et al*., 2004).

It has been demonstrated that Silicon(Si) increases plant resistance to a range of diseases, including blast (Alves *et al*., 2021) and blight (Araujo *et al*., 2016) in cereals, powdery mildew in wheat and other crops (Lepolu *et al*., 2016 and Remus-Borel *et al*.,2009). When the pH of the solution is lower than 9, Si is absorbed by roots as orthosilicic acid [$Si(OH)_4$], an uncharged monomeric molecule. Plants synthesize Silicon-rich structures of Microscopic (ultrastructural), macroscopic (bulk), and nanometric (molecular). 90% of the Silicon that is absorbed is converted into different kinds of phytoliths or Silicon–cellulose structures, which are symbolized by amorphous silica. At the nanoscale level, distinct cell or inter-cell structures are produced by partially biogenic silica (Mann *et al*., 1996). Si can effectively enhance the resistance levels of different plants to pests and pathogens (Luyckx *et al*., 2017). Thus, Si plays very important roles in ameliorating plant resistance to biotic and abiotic stresses.

Considering the above facts; the present investigation has been taken to evaluate the following objectives:

1. To study the effect of different doses of Silicon dioxide on leaf blight (*Bipolaris sorokiniana*) and on yield and yield components of wheat.
2. To find out the best performing variety of wheat against *Bipolaris* leaf blight by applying Silicon dioxide.
3. To study the effect of Silicon dioxide on seed health status of wheat.

CHAPTER II

REVIEW OF LITERATURE

This chapter presents a comprehensive review of research in relation to the effects of Silicon dioxide on *Bipolaris* Leaf Blight and on yield performance of wheat. An emphasis has been given to the recent literature.

2.1.1 *Bipolaris* blight disease of wheat

Devi *et al*. (2018) and Gultyaeva *et al*. (2018) stated that *Bipolaris* leaf blight is a common disease on wheat in all continents.

Gupta *et al*. (2018a) and Gupta *et al*. (2018b) and Al-Sadi (2016) stated that *Bipolaris* leaf blight is a common disease on wheat in all continents.

According to Sharma *et al*. (2018), Sultana *et al*. (2018), Joshi *et al*. (2007), Van Ginkel and Rajaram (1998); the hotspot for *Bipolaris* leaf blight disease is in South Asia.

A study by Singh (2017) and Kumar *et al*. (2002) in India and Brazil have shown that *Bipolaris* leaf blight is usually favored by warm weather.

According to Ayana *et al*. (2018) and Devi *et al*. (2018) yield losses due to *Bipolaris* leaf blight are high, especially in warmer areas of the world. They have been reported to reach 16%–43%.

Viani *et al*. (2017) showed that high humidity is an important factor in enhancing symptom development. Gupta *et al*. (2018a) conducted a study which showed that infection usually starts on the older leaves.

Duveiller and Sharma (2009) added that water stress and terminal heat stress have negative effects on the resistance of wheat to *B. sorokiniana*.

2.1.2. Leaf Blight Pathogen "*Bipolaris sorokiniana*": Taxonomy and Nomenclature

Gupta *et al*. (2018a) and Duveiller *et al*. (2005) showed that On the leaf surface, the conidia (15–20 μm * 60–120 μm) that are born on conidiophores (100—150 μm 6–8 μm long) emerge in the air. A single conidium (monosporic) or several conidia (polysporic) may be carried by

each conidiophore. These conidia have an olive brown color, an oblong shape, thick walls ranging from 3 to 9 μm, and a noticeable basal scar that taper towards the edge. Numerous conidial cycles are typically generated during the cropping season and spread into the air, resulting in secondary infections.

As the statement of Manamgoda *et al*. (2014) the morphology of the conidia and conidiophores is used to distinguish between various *Bipolaris* species, including *B. sorokiniana*. For this reason, a key featuring descriptions of every species of *Bipolaris* has been prepared.

Rossman *et al*. (2013) stated that When a species of *Helminthosporium* with fusoid conidia exhibiting bipolar germination was first described as *Bipolaris* in 1959, species *B. maydis* was considered to be the typification of the genus. Lately, the International Fungal Taxonomy Committee conducted an online vote that supported the recommendation to keep the term *Bipolaris* instead of *Cochliobolus*. The majority of *Bipolaris*/*Cochliobolus* species were distinguished by the morphology of their conidia and conidiophores. The teleomorphic ascospores' form and color within the *Cochliobolus* genus—typified by *C. heterostrophus* and *C. sativus*—were less remarkable. The sexual form of the anamorph *B. sorokiniana* is teleomorphic to *Cochliobolus sativus*, as demonstrated by multiple studies utilizing molecular data. The idea that the anamorphs *B. sorokiniana* and *Cochliobolus sativus* represent two stages of the same species was supported by the analysis of ribosomal DNA polymorphism, including 28S rRNA, 5.8S rRNA, and internal transcribed spacers (ITS1 and ITS2), as well as other protein-coding barcoding genes, such as GAPDH coding genes and elongation factor 1α.

Manamgoda *et al*. (2012) reported that *Bipolaris sorokiniana* is an important fungal pathogen found in wheat, barley, maize, and other small grain cereals. It causes a number of diseases, including leaf spot, common root rot (CRR), blight. There are numerous synonyms for *Bipolaris sorokiniana*, such as *Helminthosporium sativum*, *H. sorokinianum*, *Drechslera sorokiniana*, and teleomorph *C. sativus*.

2.1.3. Symptoms of *Bipolaris* Leaf blight

Aggarwal *et al*. (2019), Devi *et al*. (2018), Gupta *et al*. (2018a), Gupta *et al*. (2018b) *Bipolaris sorokiniana* is the pathogen responsible for *Bipolaris* leaf blight disease in wheat.

Gupta *et al*. (2018a, 2018b) described that *Bipolaris* leaf blight symptoms appear as brown lesions with yellow halos, which enlarge with time to cover larger areas of the leaf. Lesions can turn olive brown in color, especially under humid conditions that promote sporulation of the fungus.

According to Carmona *et al*. (2006) the symptoms of *Pyrenophora tritici-repentis*-induced tan spot, and *Alternaria* leaf blight resemble those of *Bipolaris* leaf blight. One difference is that tan spot is characterized by the appearance of dark fruiting structures, called pseudothecia, on wheat straw, which is not the case for *Bipolaris* leaf blight.

Viani *et al*. (2017) and Neupane *et al*. (2010) observed that *Bipolaris* leaf blight differs from *Alternaria* blight by the development of dark spot areas, which represent masses of conidia that are produced at later infection stages.

Chand *et al*. (2010) stated that the *Bipolaris* leaf blight symptoms elongate and coalesce.

2.1.4. Infection Area of *Bipolaris sorokiniana* Pathogen

A Research of Sprague (1950) showed that Leaf infection by *B. sorokiniana* could come from seeds, root or air. If the pathogen is in the soil, then infection could occur through stomata on the hypocotyl, from where the fungus progresses to the root, shoot and coleoptile.

Raguchander *et al*. (1988) found that Spore germination can occur within 4–6 hour and penetration by *B. sorokiniana* occurs through stomata and epidermis.

2.1.5. Host Range and Pathogenic Variability

Sultana *et al*. (2018) and Gurung *et al*. (2013) identified and investigated that the heterogeneity among *B. sorokiniana* isolates was using morphological, pathological, and molecular methods by The habitats in which *Bipolaris sorokiniana* can survive are diverse.

According to Singh *et al*. (2016b) and Manamgoda *et al*. (2012) it can also infect *Durum* wheat *(T. durum), Dicoccum* wheat (*T. dicoccum*), barley *(Hordeum vulgare*), *Triticale* rye (*Secale cereale*), maize (*Zea mays*), pearl millet (*Pennisetum typhoides*), foxtail millet (*Setaria italica*), tufted airplant (*Guzmania* species), and Panicum.

A study of Acharya *et al*. (2011) carried out in northeast China revealed that *B. sorokiniana* can infect 29 crop species, including some grasses.

Ghazvini and Tekauz (2007) used 12 differential lines and eight virulence groups were identified from 127 *B. sorokiniana* isolates that were obtained from barley.

Arabi and Jawhar (2004) found in another analysis there was significant variation in the virulence of *B. sorokiniana* from Syrian barley across barley lines with different resistance levels.

Using 12 differential barley lines, an Australian Knight *et al*. (2010) conducted a study where 31 *B. sorokiniana* isolates obtained from barley and wheat revealed 11 pathotypes.

Mahto *et al*. (2012) tested eight *B. sorokiniana* isolates for aggressiveness on eight different wheat cultivars at the seedling stage by He found that the interactions between wheat cultivars and fungal isolates vary.

Gurung *et al*. (2013) examined 96 *B. sorokiniana* isolates by using twelve different wheat lines. He stated that his isolates were categorized into 47 pathotypes based on the analysis of phenotypic data. One type of pathotype may be more virulent than another in regions where wheat is consistently planted.

Chand *et al*. (2003) and Pandey *et al*. (2008) added that nuclear migration, hyphal fusion, and the formation of a multinuclear state have the potential to impact virulence.

Zhong and Steffenson (2007) used CHEF electrophoresis to examine the karyotypes of 16 isolates obtained from barley grown in various parts of the world (Brazil, Canada, Japan, Poland, Uruguay and the United States), representing all three pathotypes (0, 1, 2). Unless large-scale structural changes were involved in differentiation, 14 of the 16 isolates (except North Dakota isolates ND90Pr and ND91-Bowman) each displayed a distinct banding pattern, which is surprising.

Zhong and Steffenson (2001) showed that within the *B. sorokiniana* population, recombination, migration/gene flow, and mutation are the main causes of genetic variation amongst isolates. Recombination between isolates with high virulence levels may happen in the pathogen's population.

2.1.6. Disease Cycle and Epidemiology of the Disease

Gupta *et al*. (2018a) spot blotch causes photosynthesis loss, premature leaf senescence, reduced grain filling, low kernel weight and extreme grain yield reductions combined with terminal heat stress. The disease is expected to become a more severe constraint for wheat production if the forecast that air temperature will rise in the coming decades is accurate.

According to Acharya *et al*. (2011), conidia that are airborne germinate and form germ tubes on the surface of leaves.

According to Chand *et al*. (2010) the pathogen's subsequent development and growth accelerates damage to the leaves and spikes, which lowers yield.

Aggarwal *et al*. (2008) and Kumar *et al*. (2002)Reis and Forcelini (1993) reported that the pathogen appears after the host seed germinates and moves quickly to the plumule and eventually the coleoptile tip. The pathogen grows as a hemi-biotroph during its biotrophic phase, which is limited to individual epidermal cells, and during its necrotrophic phase, which involves host cell apoptosis. In addition, *Cochliobolus sativus* is thought to be a rare sexual condition that does not spread infection or act as a source of inoculum.

Rosyara *et al*. (2007, 2008) and Regmi *et al*. (2002) reported that although *B. sorokiniana* is a relatively weak parasite, its effectiveness is primarily based on how compromised host plants respond to different environmental stresses, including water stress, nutrient deficiency, and high temperatures. Numerous stressors reduce plant fitness, which makes *B. sorokiniana* more invasive and encourages leaf blight disease.

Sharma and Duveiller (2006), Gupta *et al*. (2018a) anticipated that the leaf blight disease will get worse in the future due to the growing issues of climate change, malnutrition, and water scarcity.

Jansson and Akesson (2003) found that Appressoria appear in 8 hours, and then infecting hyphae multiply in the mesophyll tissue of the leaf by invading the cells mentioned by Acharya *et al*. (2011). Additionally, Eisa *et al*. (2013) verified direct penetration.

A research by Joshi *et al*. (2007c) reported that spot blotch flares up in response to favorable weather conditions, such as warm air temperatures, leaf wetness lasting more than 12 hours, and plant age especially after ear emergence

Additionally, Joshi *et al*. (2007c) and Duveiller *et al*. (2005) showed that an increasing number of cloudy and foggy days from November to February aided in the pathogen's early establishment.

2.1.7. Fungal pathogens associated with wheat seed and their effect on quality of wheat

Tonu (2006) found 13 fungi were associated with farmers' saved wheat seed of different location in which, the pathogenic in order of prevalence were *Bipolaris sorokiniana*, *Alternaria* tenuis, *Curvularia lunata*, *Fusarium* oxysporum, and *Aspergillus flavus*. The incidence of fungi in both unclean and clean seed varied with respect of location of seed collection. AIl fungal pathogens were more prevalent in farmers saved seed compared to clean seed. Clean seed gave higher counts of normal seedlings and lesser percentage of abnormal seedings and dead seed over unclean farmers seed. Clean seed resulted higher germination and seedling vigour index Over unclean and abnormal seed.

Naznin *et al*. (2005) observed that Viability of wheat seed decreased with the increase of storage period. *Bipolaris sorokiniana, Fusarium oxysporum, Aspergillus flavus, Rhizopus* sp. and *Alternaria* teuis were found to be associated with seed sample and their prevalence was highest when stored in gunny bag while lowest in tin containers.

According to Hanson and Christensen (1953) fungi were connected to wheat seed. Discolored wheat seed was found to be associated with *Helminthosporium* sp. and *Alternaria* sp. They discovered that while Fusarium sp. was common in many seed lots, it was not the cause of wheat's black point.

Fakir (1988) found five distinct black point fungi were found in black point-affected seed. These included *Fusarium* sp., *Drechslera sorokiniana, Alternaria tenuis, Cladosporium cladosporioides,* and *Curvularia lunata*. Of these, *A. tenuis* and *D. sorokiniana* seemed to be the most common fungi. Among the black point fungi *D. sorokiniana* and *Fusarium* sp. were found pathogenic.

Rashid *et al*. (1992) collected highest seed borne of *Bipolaris* in cv. Sonalika from Mymensingh (27.4 %) and Meherpur (25.7 %) and lowest in cv. Kanchan from Pabna.

Janczak and Pokacka (1993)) in Poland worked on winter wheat and recorded *Alternaria* spp. and *Epicoccum* spp. as the most common fungi on surface disinfected wheat seed. Other fungi were *Fusarium spp., Drechslera tritici-repentis (Pyrenophora tritici-repentis), Seploria nodorum (Leptosphaeria nodorum)* and *Bipolaris sorokiniana* (*Cochliobolus sativus*).

Dhruj and Siddigui (1994) discussed the relationship between various fungi and wheat grains. The frequency of fungi varied according to the zone. They isolated the following common *mycoflora: F. moniliforme, F. semitectum, Curvularia Iunata, C. pallescens, Trichothecium roseum, Nigrospora* sp., *Ulocladium* spp., *Stemphylium* sp., *and Verticillium* sp.

According to Khan and Bhutta (1994), *Drechslera sorokiniana* was identified as the primary wheat seed-borne fungus by with *Fusarium moniliforme* and *Cephalosporium acremonium* following closely behind.

Alam (1980) identified eighteen fungal species, belonging to eleven genera, from newly harvested wheat seed cultivated in Bangladesh. Among them, *Drechslera sorokiniana* was discovered to be pathogenic, resulting in wheat leaf blight. However, in the seeds of seven carefully chosen wheat cultivars that were gathered over the course of two seasons from five agricultural research station Gazipur, Ishwardi, Jamalpur, Jashore, and Mymensingh.

Ali and Fakir (1992) found 16 fungi representing nine genera. It was discovered that *Bipolaris sorokiniana* was one of the most common fungi. In Bangladesh, eight different species of *Bipolaris* were identified using the freezing blotter method.

Rashid *et al*. (1992) reported that *B. sorokiniana (Cochliobolus sativus)* was the most prevalent species.

In another study Ahmed *et al*. (1994) investigated fungi associated with developing wheat grains in a black point susceptible wheat variety Kanchan. They isolated 11 species of fungi representing 10 genera. The common fungi in the order of prevalence were *Cladosporium cladosporioides, Epicoccum purpurascens, Alternaria tenuis (Alternaria alternata), Fiusarium spp*. and *Bipolaris sorokiniana (Cochliobolus satius*). Population of *C. cladosporioides and Fusarium spp*. decreased and those of other fungi gradually increased with the increase in age of the developing grain.

Babadoost (1995) detected *Fusarium* spp. in 62 of 65 wheat seed samples collected with average seed infection of 22,4%. Eight *Fusarium* spp. Including- *acuminatum, F. culmorum, F. equisetti, F. graminearum, F. oxysporum. proloferatum, F. semitectum and F. solani* were isolated from seed and plants.

Milosevice *et al*. (1995) identify 21 species of fungi from wheat, in which the majority belonged to the genus *Fusarium*. Storage fungi belonging to *Penicillium, Aspergillus, Rhizopus* and *Mucor* genera were also present.

Parashar and Cholan (1967) found that *Alternaria* and *Helnminthosporium* affected wheat grain reduced germination by 34.00% in the laboratory and caused 41.07% vield loss in the field.

Kachalova and Kuz'michev (1969) observed that *Alternaria tenuis (A. alternata*) attacked winter wheat more frequently, while *Helminthosporium sativum (Cochliobolus sativus)* caused more damage to spring wheat. Both the pathogen reduced seed germination. Incidence of black embryo in the Moscow regions of U.S.S.R was low in winter wheat (1.6%) but higher on spring wheat (10.5% and more).

According to Huguelet and Kiesling (1973), Adlakha and Joshi (1974) *Drechslera sorokiniana, Helminthosporium sativum* was most destructive pathogen in causing grain infection, decreases

the kernel weight, discolored the kernel, reduced the size & shriveled the grain and decrease seed germination.

A report by Ali (1981) Germinating seed of wheat and seedling were mostly affected by *Alternaria temuis, Drechslera sorokiniana* and *Fusarium* sp.

Sinha and Thapliyal (1984) stated that Triticale seed, infected with black point when planted on PDA, yielded *Helminthosporium sativum* (57%) and *Aliternaria tenuis* (35%), the remaining 8% showed undetected fungi. It was concluded that *H. sativum* and *Alternaria tenuis* are the two main organisms associated with black pointed grains. But in another study Saari and Prescott (1986) reported that *Alternaria* tenuis is not harmful at all and does not affect the seed germination, it only discolors the embryo end of wheat seed. *Drechslera sorokiniana* causes some reduction in seed germination discoloration of embryo end of seed, while *Fusarium* spp. causes whitish to pinkish discoloration of such grains.

Agarwal *et al*. (1993) found three categories of disease symptoms in black point of wheat. Those with a light brown to dark brown discrete lesion and a dull white spherical or elliptical areas in the center showed infection by *Drechslera sorokiniana* alone. Grain with dark brown to black discoloration, which generally restricted the area around the embryo, showed 100% infection by 4. alternata. The grains in the third category were mostly lighter in weight, creamy white or pinkish in color, and infected with *Fusarium graminearum* (*Gibberella zeae*).

Santorelli and Porta-Puglia (1996) investigated the condition of soft and durum wheat. The most common sources of contamination or infection of seed were *Fusarium* spp. and *Microdochium nivale,* with a few samples exhibiting a high concentration of *Bipolaris* sorokiniana.

Mahmud (2005) investigated Rangpur district farmers' wheat seed quality and condition. In all, he discovered that over 80% of the samples from Rangpur sadar and 12 out of 20 samples from Mithapukur thana appeared to be healthy seed. From the seed samples, he isolated seven fungi, the most common of which was *Bipolaris sorokiniana*. Fungi became more associated as the severity of black points increased.

2.2.1. Distribution of Silicon in Plants

According to the study of Yamini *et al*. (2008). Adrees *et al*. (2015) Si is a component of all plants, although the amount varies greatly between species. In general, monocotyledonous plants have a substantially higher Si content than dicotyledonous plants. They classified plants into three groups based on the different amounts of Silicon they contain: high, like rice and horsetail, which contain 10–15% Si; intermediate, like sugarcane, which contain 1-3% Si; and low, like tomato and pea, which contain less than 0.5% Si.

Gong *et al*. (2004) reported that yet there are also noticeable variations in the Si concentrations across various sections of the same plant. Within the same plant, the types of Si distribution are as follows: (1) Low-Si plants, like tomato and cabbage, have a Si content that is roughly equal to or slightly higher than that of the root system; (2) Middle-Si plants, like crimson clover, have a root level that is approximately eight times that of the shoots; and (3) High-Si plants, like rice and oats, have a Si content that is primarily concentrated in the shoots. Since the majority of Silicon in plants is found in the apoplast, the majority of Silicon in rice accumulates in the cell wall, cell lumen, and intercellular space, or in the space between the stratum corneum and the epidermal cells. A double layer known as the cuticle–Si layer is formed by Si deposits in the epidermal cells of rice leaves. Si is deposited in the parenchymal and epidermal cell walls of a leaf sheath. It is mostly found in the sclerenchyma, parenchyma, vascular bundles, and cell walls of epidermal cells in stems. It is mostly deposited in vascular bundles and the gaps between the cuticle and epidermal cells in inflorescences and rice husks.

Ma *et al*. (2006) reported that the Si distribution in the roots is relatively uniform, but mainly concentrated in maturation zone, with less Si being deposited in the elongation zone.

2.2.2. Absorption of silicon dioxide by plants

The plant species and the chemical form of the Si in the soil are the main determinants of the uptake of Si from the soil. Plants are only able to absorb monosilicic acid, which has the chemical formula $Si(OH)_4$.

According to Mitani *et al*. (2005) rice, cucumber, and tomato absorb Si from the soil through their roots, which subsequently go to cortical cells and xylem vessels.

Ma and Yamaji (2006) & Ma and Takahashi (2002) found When the pH of the soil solution is less than 9, Silicon is absorbed by plant roots as noncharged monosilicic acid.

According to Datnoff *et al*. (2007) respiration rate plays a major role in the absorption of monosilicic acid.

Mitani *et al*. (2005) reported that the insoluble silica known as species-specific solid bodies (phytoliths) is created when monosilicic acid polymerizes at a concentration of about 2 mm.

As a finding of Datnoff *et al*. (2007) silica deposited in the intercellular spaces, cell walls, and subcuticular layer that surrounds the leaf cells.

Furthermore, Ma and Takahashi (2002) made a comparison that mature leaves accumulate more Silicon young leaves.

Datnoff *et al*. (2007) found that a significant portion of dissolved Silicon that results from phytolith dissolution, or litterfall decomposition, is absorbed by plants.

According to Ma and Yamaji (2006) Depending on the plant genotype, soil Silicon concentration, and environmental factors, the amount of absorbed Silicon in plants can range from 0.1 to 10% dry weight.

2.2.3. Accumulation of silicon in plant species

According to Epstein (2009) it was previously thought that Silicon had no effect on healthy plants' metabolism in the absence of abiotic and/or biotic stresses, indicating that Silicon is not necessary.

However, Rodriges and Datnoff (2005) showed that Silicon nutrition increased the agronomic yields of unstressed crops like rice.

The agricultural perspective of Ma and Yamamaji (2006) states that the uptake of Silicon was significantly higher in *graminaceous* plants (i.e., wheat, oat, rye, barley, sorghum, maize, and

sugarcane) than in other plant species. Rice was one common example, absorbing 150–300 kg Si/ha.

Snyder *et al*. (2006) showed that high silicon accumulation in rice is essential for both high and stable production and healthy plant growth.

In addition, according to Savant *et al*. (1997) *graminaceous* plants absorb Silicon at concentrations that are on the same level with or more than those of some essential nutrients, such as N and K.

Rodriges and Datnoff (2005) reported that silicon accumulation in rice was roughly 108% higher than nitrogen accumulation.

Ma and Yamaji (2006) reported that silicon is absorbed inertly by most dicotyledonous plants, including cucumbers, melons, strawberries, and soybeans. However, a number of plants, particularly dicotyledons like beans, tomatoes, and other plant species, are incapable of absorbing Silicon from the soil.

Datnoff *et al*., (2007) claimed another criterion for classifying a species of plant as a Silicon absorber is the Si/Ca ratio.

2.2.4. Importance of silicon in plant crops

It has been reported that Silicon improves and increases plant yield, growth, and production. It enhances a number of plant species' morphological and mechanical traits, including height, stature, root penetration into the soil, leaf exposure to light, and resistance to lodging.

According to Datnoff *et al*. (2007) silicon decreases transpiration, improves plant resistance to salinity, metal toxicity, and drought stress, and raises enzyme activity. In contrast, silicon accumulation in plants is crucial for their defense against insect herbivores under biotic stress conditions.

Furthermore, Van Bockhaven *et al*. (2013) and Zellner *et al*. (2011) demonstrated that silicon strengthens plants' defenses against a range of bacterial, viral, and fungal diseases.

According to Van Bockhaven *et al*. (2013), Epstein (2009), Ma and Yamaji (2006) and Fauteux *et al*. (2005) the most intriguing finding is that silicon shields plants from a variety of stresses without causing resistance trade-offs or consequences to growth and yield.

Reynolds *et al*. (2009) reported when feeding on plants high in silica, a number of herbivorous insect experience negative effects.

2.2.5. Physical defense by silicon against pathogen

According to the first theory of Silicon's physical enhancement of resistance, silicon that is deposited on the surface of tissue serves as a physical barrier to keep fungi out of plants. According to Van Bockhaven *et al*. (2013), Datnoff *et al*. (2007) and Fauteux *et al*. (2005) the density of the long and short silicified cells found in the leaf epidermis, the thick silica layer beneath the cuticle, the double cuticular layer, the thickened Silicon-cellulose membrane, and the formation of papillae are all linked to an increase in resistance (Silicon mechanically strengthens plants, inhibits the physical entry of pathogenic fungi, and/or reduces the plant cell's vulnerability to enzymatic fungal pathogen degradation.

Yoshida *et al*. (1962) reported that following the polymerization of monosilicic acid, a thick layer of silica is formed beneath the cuticle of rice leaves and sheaths. Pathogen penetration may be partially inhibited by this Silicon layer under the cuticle.

Volk *et al*. (1958) reported that Silicon may combine with organic substances found in the epidermal cell wall to strengthen the cell's defense against enzymes released by plant pathogenic fungi.

Inanaga *et al*. (1995) found lignin-carbohydrate complexes in the cell walls of epidermal cells have been linked to Silicon.

According to Rodrigues *et al*. (2001) and Seebold *et al*. (2004) silicon deposited on the tissue surface reduces the number of lesions on leaf blades or lengthens the incubation period, as reported for the *Pyricularia grisea*– and *Rhizoctonia solani*–rice pathosystems. These cytological and pathogenic features are linked to physical resistance.

Van Brockhaven *et al*. (2013) proposed and subsequently strongly argued and questioned that fungal pathogen resistance in Silicon-treated plants was far more complex than physical resistance.

2.2.6. Silicon effect on Wheat

According to Domiciano *et al*. (2010) the use of Silicon was also found to improve resistance of wheat leaves to *B. sorokiniana* infection. This work aimed to evaluate the effect of Silicon(Si) on the progress of *Bipolaris sorokiniana* management, on the flag leaf of wheat plants. The severity of brown spot on the flag leaf was significantly lower in plants supplied with Si at all evaluation time. For spot blotch (*Bipolaris sorokiniana*) the AUDPC was reduced by 59% due soil fertilization with calcium silicate (wollastonite).

Fauteux *et al*. (2005) reported the success of Si application in reducing the incidence or severity of several diseases in diverse crops, including wheat. The expansion of the wheat crop in Brazil occurs mainly in the Cerrado region, where soil Si availability is low. Due to the attributes of Cerrado soils, it is to be expected that the plant response to Si application will be positive, mainly for Si-accumulating plants, as in the case of crops of the *Gramineae* family, including wheat. Rafi & Epstein (1999) found that Si is absorbed as monosilicic acid (H_4SiO_4) and the wheat root system is efficient in Si uptake.

2.2.7. Enzyme activity in plants with Silicon

Numerous investigations by Van Bockhaven *et al*. (2013), Datnoff *et al*. (2007) and Fauteux *et al*. (2005) revealed a correlation between increased protective enzyme activity and reduced disease severity. After a fungal infection, Silicon has been shown to promote the build-up of defense-related enzymes in plant leaves.

According to Yang *et al*. (2003) Silicon treatment increased the peroxidase activity in wheat leaves, which reduced the severity of powdery mildew caused by *Blumeria graminis f.* sp. *tritici.*

CHAPTER III

MATERIALS AND METHODS

The materials and methods followed in this experiment to achieve the intended objectives are described in details in this chapter. For convenience, this chapter has been divided into several sections such as Fungi isolation and identification, site and soil, crop, land preparation, experimental design, treatments, fertilizer application, seed sowing, intercultural operations, data collection, harvesting, and statistical analysis.

3.1 Isolation and identification of pathogen

Isolation and identification of pathogen were made by two ways

a. By direct inspection

b. By inoculating sample tissue on PDA medium

(a) By direct observation

Bipolaris blight symptoms typically appear on the leaf, sheath, node and glumes as small light brown lesions, mostly oval to oblong to somewhat elliptical in shape. These lesions have brown margins and are often scattered throughout the leaves and gradually increase in size and coalesce to form larger necrotic patches. The affected leaves soon become chlorophyll deficient and eventually die. The diseased leaves of wheat plants were collected and kept in polythene bags and tagged. The samples were then taken to the laboratory. Then slides were prepared from the diseased samples, observed under microscope and the pathogen was identified according to CMI description.

b. By inoculating sample tissue on PDA medium

Bipolaris leaf blight infected sample(leaves) were collected from the HSTU research field, Dinajpur. The diseased samples were initially washed in tap water to remove dust particle. Then specimens were cut into small pieces (5mm) along with healthy and dead tissue and then surface sterilized with 0.1% NaOCl for 1 minutes and rinsed in sterilized water for three times (Mian, 1995). Then infected leaf pieces were placed on filter paper to remove excess water. The pieces were placed in petri plates containing sterilized (PDA Potato Dextrose Agar) @15 ml/plate and aseptically with equal distance. The plates were incubated at 26°C for 7 days. The colonies of the fungal pathogens grew were isolated. The isolates were purified. The selected

isolates of *B. sorokiniana* were cultured on PDA medium and kept at 10°C for further use. (Figure 17)

3.2. Location of experimental field

The experiment was conducted in the research field of Hajee Mohammad Danesh Science and Technology University, Dinajpur-5200, Bangladesh from December 2022 to April 2023. The geographical position of the experimental area and location is between 25°41'46.3"N and 88°39'01.1" E and 40 m above sea level shown in (Appendix. I). The Agro Ecological Zone (AEZ) of the area is the Old Himalayan Piedmomt Plain (AEZ-1). This has largest wheat area and also produces largest amount of wheat in the country.

3.3. Soil type

The soil of the experimental field belongs to the old Himalayan Piedmont Plain (AEZ-1). Soil analysis was done from SRDI (Soil Resource Development Institute), Noshipur, Dinajpur, Bangladesh. Soil analysis showed that the soil of the experimental plot was sandy loam. with good drainage capacity. The experiment plot was medium high land with the pH range of 6.12 i.e., the soil is acidic soil. The soil physical and chemical properties of the experimental site were analyzed before started the experiment and presented in Appendix II.

3.4. Experiment design:

The experiment consists of two factorial designs. One is variety and another one is Silicon dioxide as chemical fertilizer.

3.5. Duration of the experiment

The experiment was conducted during the period from December 2022 to April 2023

3.6. Varieties/ planting material

V1 = BWMRI Gom -1

V2 = BWMRI Gom -2

were used in this experiment. Seeds were collected from Bangladesh Wheat and Maize Research Institute, Dinajpur (BWMRI).

3.7. Main features of the varieties

The wheat varieties were BWMRI Gom -1 and BWMRI Gom -2. Both of these varieties are popular and developed by Bangladesh Wheat and Maize Research Institute, Dinajpur (BWMRI).

3.7.1. Varietal characteristics of BWMRI Gom -1

- The height of the plant is 90-100 cm with four to six buds.
- It takes 53-57 days to start flowering and 105-112 days to get maturity from sowing.
- The pods are long and the number of grains per pod is 45-50.
- The seeds are white in color, shiny and large in size.
- The variety is resistant to wheat leaf spot disease and rust disease.
- The plant is short and does not tip over easily.
- The variety is early and heat tolerant.
- Yield is 4000-5000 kg per hectare under suitable conditions.
- 1000 seeds weigh 52-60 grams.

3.7.2. Varietal characteristics of BWMRI Gom -2

- The height of the plant is 97-106 cm with four to six buds.
- The leaves are broad and dark green.
- It takes 68-72 days to start flowering and 108-115 days to get maturity from sowing.
- The pods are long and the number of grains per pod is 45-48.
- The color of the grains is white, shiny and medium in size.
- The variety is resistant to leaf rust, spot disease and blast disease and heat tolerant.
- Yield per hectare is 4500-5800 kg under suitable conditions.
- 1000 grains weight 45-50 grams.

3.8. Treatments

T_1 = Silicon dioxide @ 60 kg ha^{-1}

T_2 = Silicon dioxide @ 120 kg ha^{-1}

T_3= Silicon dioxide @ 180 kg ha^{-1}

(Silicon was applied as Silicon dioxide di oxide (SiO_2)

3.9. The treatment combinations are as follows

Table 1. Treatment combinations

1) T_1× V_1 = Silicon dioxide @ 60 kg ha^{-1} × V_1 (BWMRI Gom -1)
2) T_2× V_1= Silicon dioxide @ 120 kg ha^{-1} × V_1(BWMRI Gom -1)
3) T_3× V_1= Silicon dioxide @ 180 kg ha^{-1} ×V_1(BWMRI Gom -1)
4) T_1× V_2= Silicon dioxide @ 60 kg ha^{-1} × V_2(BWMRI Gom -2)
5) T_2× V_2= Silicon dioxide @ 120 kg ha^{-1} × V_2(BWMRI Gom -2)
6) T_3× V_2= Silicon dioxide @ 180 kg ha^{-1} × V_2(BWMRI Gom -2)

3.10. Replication

Three (3) replications were followed in this research. Therefore, the total number of plots were, 3×3×3×2 = 54. Here, three plots were chosen alongside for each Treatment × Variety in a replication, which included three treatments and two varieties.

3.11. Experimental layout and Treatment combinations

The experiment was laid out in a Randomized Complete Block Design (RCBD). The unit plot size was (2 m × 2 m) i.e., $4m^2$. Irrigation and drainage channel was made by maintaining 50 cm width and 30 cm depth between the blocks and 25 cm wide and 25 cm depth between plots. The experimental layout and treatment combinations are shown in Appendix III.

3.12. Experimental procedure and crop management

3.12.1. Land preparation

The experimental field was first ploughed on 10 December 2022. The clods of the land were hammered to make soil into small pieces. Weeds, stubbles, and crop residues were removed from the land. The final ploughing and land preparation was done on 15 December 2022. The layout was done as per experimental design on 17 December 2022.

3.12.2. Silicon dioxide application

Silicon dioxide was applied to the soil at 24g/plot as T_1, 48g/plot as T_2 and 72g/plot as T_3 in four different times (first application was at final land preparation, second application was at 25DAS, third application was at 50 DAS and Fourth application was at 75DAS).

3.12.3. Seed rate with spacing

The recommended seed rate (120 kg ha-^{1}) i.e., 0.048 kg or 48 g plot^{-1} of wheat variety seed was used for a single plot. So, a total of 2592 g or 2.6 kg seed was required for a 216m^{2} area. Line to line distance was 28 cm. The seeds were covered with loose, friable soil after being placed in a line.

3.12.4. Seed sowing

After preparing the line spacing, seeds were sown in line on 19 December 2022 as per the experimental layout.

3.12.5 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:

3.12.5.1 Irrigation and weeding

After sowing, there was a light irrigation. Three irrigations were done at various critical stages following the development of the seedlings. For instance, the first irrigation was carried out at the crown root initiation stage (CRI), i.e., (20 DAS); the second irrigation was carried out at the maximum tillering stage (40 DAS); and the third irrigation was carried out at the heading stage, or 50–60 DAS. When watering, care was taken to ensure that the water did not flow over the plot boundaries or move from one plot to another. The field's excess water was drained.

3.12.5.2 Weeding

The plots were infested with some common weeds, namely Batua (*Chenopodium album*), Durba (*Cynodon dactylon*), mutha (*Cyperus rotundus*), Shetodrone (*Leucas aspera*) and sushni shak (*Marsilea quadrifolia*) which were removed by uprooting by hand from the field near about three times during the cropping period.

3.12.5.3 Insect and pest control

In the field, termites, stem borer, and aphids were among the insects that caused some damage. Aktara @ 0.2 g L^{-1} water was used to control these insect pests.

3.12.6. Harvesting

The crop was harvested at maturity on 29 march 2023. The harvested crop from each plot was bundled separately and brought to the threshing floor of the HSTU farm. The crops were threshed, cleaned, and processed on 1 April 2023. Then sundry weight of both grain and straw was recorded for every plot and the weight in the gram plot was converted to ton ha-^{1}.

3.12.7. Tagging and data collection

Randomly 5 plants were selected from a single plot and tagged. So, a total of 15 plants/plot (three alongside plot with similar treatment and variety) were tagged for rating and mean values were determined to get rating score of each treatment.

3.13. Data collection

3.13.1. Data collection based on yield and yield characteristics

Data were collected based on the yield and yield characteristics of the wheat plant. The characteristics were:

- Plant height (cm)
- Spike length (cm)
- Thousand seed weight (g)
- Grain yield (t ha^{-1})
- Biological yield (t ha^{-1})
- Harvest Index (%)

3.13.1.1 Plant height (cm)

Plant height was taken four times i.e., 67 DAS, 72 DAS, 77 DAS and 82 DAS. The plant height was measured from the ground level to the top of the flag leaf. From each plot, fifteen plants were selected randomly, and measured the plant height. Always measured the plant height in cm.

3.13.1.2. 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 four times i.e., 67 DAS, 72 DAS, 77 DAS and 82 DAS. It was recorded in cm.

3.13.1.3. Straw yield (t ha^{-1})

After harvesting, the straw from each unit plot was dried in the sun and weighed. The result was expressed as t ha^{-1}. Straw yield was measured by the following formula;

Straw yield = Biological yield – Grain yield

3.13.1.4. Thousand grain weight (g)

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

3.13.1.5. Grain yield (t ha^{-1})

After harvest of the crop, grain from each unit plot was dried and weighed. The result was expressed as t ha^{-1} on 14 % moisture basis. Grain yield was measured by the following formula;

Grain yield = Biological yield – Straw yield

3.13.1.6. Biological yield (t ha^{-1})

Biological yield is the total biomass produced above the soil. Biological yield was measured by the following formula and expressed in t ha^{-1};

Biological yield = Grain yield +Straw yield

3.13.1.7. Harvest Index (%)

Harvest index was determined by dividing the economic yield (grain yield) to the biological yield (grain yield + straw yield) from the same area and then multiplied by 100. It is expressed by the following formula;

$$\text{Harvest Index} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

3.13.2. Data collection on Disease

3.13.2.1. Disease severity

Percentage of leaf area infection data was taken four times i.e., 67 DAS, 72 DAS, 77 DAS and 82 DAS. 15 plants/plot were selected and data was taken from flag leaf and penultimate leaf.

3.13.2.2. Evaluation of leaf blight severity

Bipolaris Leaf Blight severity of flag leaf and penultimate leaf was counted four times in four 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):

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

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

3.13.2.3. Seed Health Study after harvesting

Health status of the seeds of different treatments was done following ISTA rules (ISTA,1999). In this method 3 layers of blotter 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 petri dish maintaining equal distance and covered with lid. Total 400 were used each treatment and variety. 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. (Figure 7)

3.14. Data analysis using Statistical program

The analysis of variance (ANOVA) function, the relationship between Silicon dioxide treatments and variety, with *Bipolaris* blight and yield attributes of wheat evaluated by the least significant difference (LSD) used for mean comparisons at a 5 % probability level using Statistix 10. Comparison graphs were done by Microsoft Excel software.

CHAPTER IV

RESULT

4.1. Disease severity

4.1.1. Disease severity of flag leaf

4.1.1.1. Interaction effect of treatment and variety on disease severity of flag leaf

Bipolaris blight disease severity (%) was recorded at 67DAS, 72DAS, 77 DAS and 82DAS. At 67 DAS the interaction effect of treatments and varieties on disease severity varied significantly. The maximum disease severity on flag leaf was recorded from T_1V_2 (3.36%) followed by T_3V_2(3.14%). T_2V_2(2.73%), T_3V_1(2.19%), T_2V_1(2.14%) and the lowest disease severity on flag leaf was recorded from T_1 V_1 (1.39%). At 72 DAS the interaction effect of treatments and varieties on disease severity varies significantly. The highest disease severity on flag leaf was recorded from T_3V_2(9.73) followed by T_2V_2(9.54%), T_1V_2 (7.75%), T_1V_1 (5.12%), T_31_1 (4.74%) and the lowest was recorded from T_2 V_1 (3.80%). At 77 DAS the interaction effect of treatments and varieties on disease severity varies significantly. T_2V_2 (11.62%) showed the highest disease severity followed by T_3V_2(11.34%), T_1V_2 (8.41%), T_3V_1 (6.32%), T_21_1 (5.62%) and lowest was T_1V_1 (5.12%). At 82 DAS the interaction effect of treatments and varieties on disease severity varies significantly. Maximum disease was recorded in T_2V_2 (15.43%) followed by T_3V_2(14.77%), T_3V_1 (12.62%), T_1V_2 (9.67%), T_21_1 (7.41%) and the lowest disease severity was recorded from T_1 V_1 (7.03%). (Table 2.)

Table 2. Effect of interactions on disease severity on flag leaf at 67 DAS, 72 DAS, 77 DAS and 82 DAS

Interactions Treatment ×Variety (T×V)	Disease severity(%) of flag leaf			
	At 67 DAS	At 72 DAS	At 77 DAS	At 82 DAS
T_1 V_1	1.39 c	5.12 c	5.12 d	7.03 d
T_2V_1	2.14 bc	3.80 d	5.62 cd	7.41 d
T_3V_1	2.19 bc	4.74 cd	6.32 c	12.62 b
T_1V_2	3.36 a	7.75 b	8.41 b	9.67 c
T_2V_2	2.73 ab	9.54 a	11.62 a	15.43 a
T_3V_2	3.14 a	9.73 a	11.34 a	14.77 a
CV	18.69	9.08	6.78	6.11
LSD	0.847	1.120	0.996	1.240

CV=Co-efficient of variance, LSD= Least Significant Difference
T1 = Silicon dioxide @ 60 kg ha^{-1}, T2 = Silicon dioxide @ 120 kg ha^{-1}, T3= Silicon dioxide @ 180 kg ha^{-1}, V_1 = BWMRI Gom -1, V_2 = BWMRI Gom -2

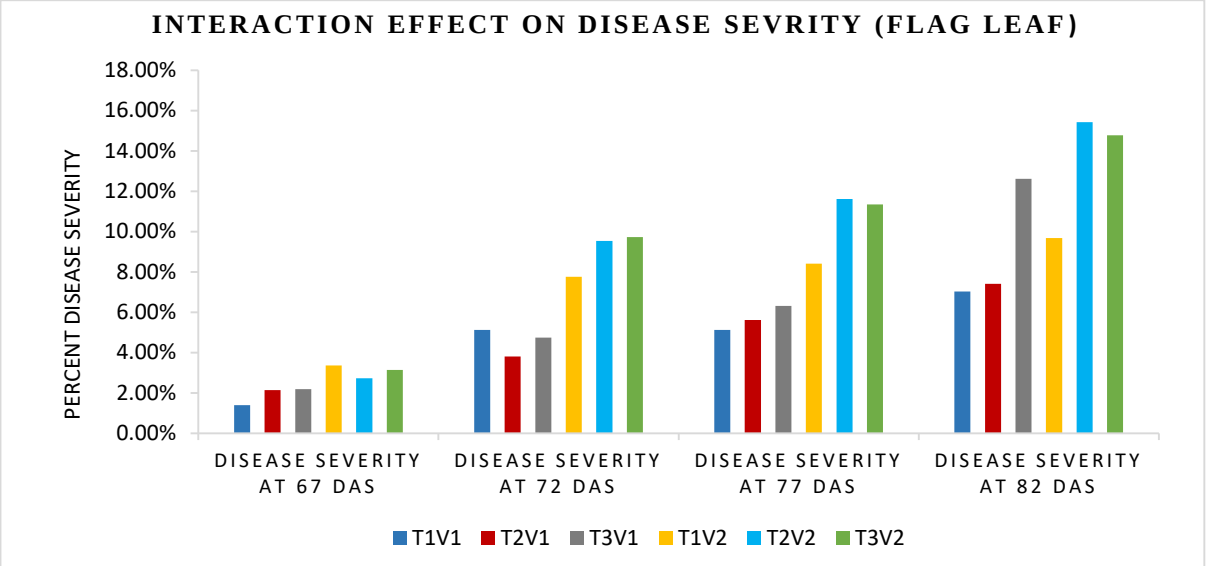


Figure 1. Effect of interactions on disease severity on flag leaf at 67 DAS, 72 DAS, 77 DAS AND 82 DAS

4.1.1.2. Effect of treatment on disease severity of flag leaf

Bipolaris blight disease severity (%) was recorded at 67DAS, 72DAS, 77 DAS and 82DAS. At 67 DAS treatment effect on disease severity of flag leaf was not varied significantly. The maximum disease severity on flag leaf was obtained from T_3 (2.66%) followed by T_2 (2.44) and the lowest disease severity was recorded from T_1 (2.37%). At 72 DAS treatment effect on disease severity of flag leaf was not varied significantly. The maximum disease severity on flag leaf was recorded from T_3 (7.23%) followed by T_2(6.67) and the lowest disease severity was recorded from T_1 (6.44%). At 77 DAS treatment effect on disease severity of flag leaf varied significantly. The maximum disease severity on flag leaf was obtained from T_3 (8.83%) followed by T_2(8.62%) and the lowest disease severity was recorded from T_1 (6.77%). At 82 DAS treatment effect on disease severity of flag leaf varied significantly. The maximum disease severity on flag leaf was obtained from T_3 (13.69%) followed by T_2(11.42%) and the lowest disease severity was recorded from T_1 (8.35%). (Table 3.)

Table 3. Effect of treatments on disease severity on flag leaf at 67 DAS, 72 DAS, 77 DAS and 82 DAS

Treatments (T)	Disease severity(%) of flag Leaf			
	At 67 DAS	At 72 DAS	At 77 DAS	At 82 DAS
T_1	2.37 a	6.44 a	6.77 b	8.35 b
T_2	2.44 a	6.67 a	8.62 a	11.42 a
T_3	2.66 a	7.23 a	8.83 a	13.69 a
CV	23.84	14.11	11.1	17.08
LSD	0.764	1.23	1.153	2.45

CV=Co-efficient of variance, LSD= Least Significant Difference
T1 = Silicon dioxide @ 60 kg ha^{-1}, T2 = Silicon dioxide @ 120 kg ha^{-1}, T3= Silicon dioxide @ 180 kg ha^{-1}

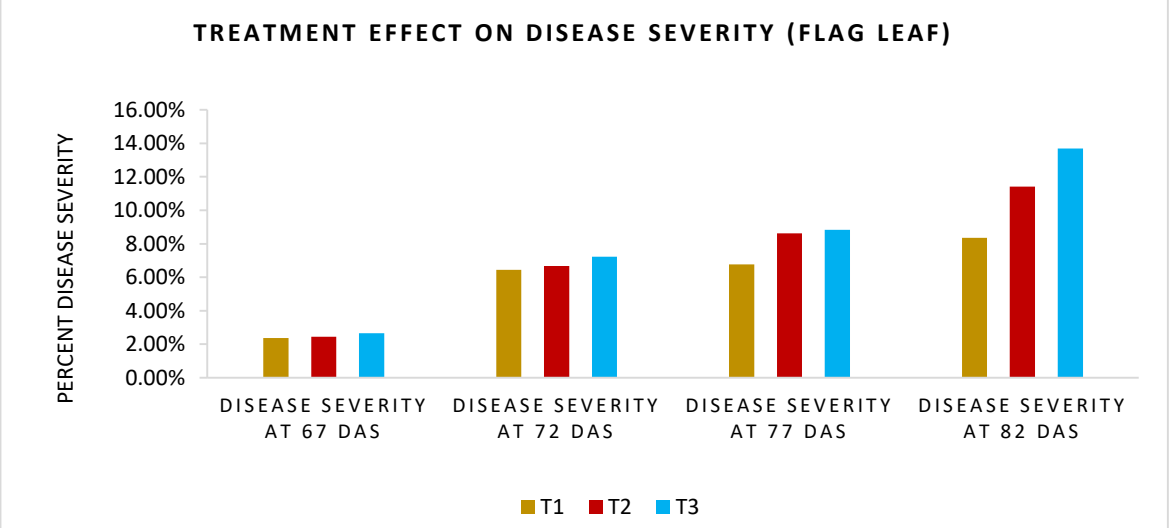


Figure 2. Effect of treatments on disease severity on flag leaf at 67 DAS, 72 DAS, 77 DAS and 82 DAS

4.1.1.3. Effect of variety on disease severity of flag leaf

Bipolaris blight disease severity (%) was recorded at 67 DAS, 72 DAS, 77 DAS and 82DAS. At 67 DAS difference in disease severity on flag leaf between the varieties is statistically significant. Maximum disease severity on flag leaf was recorded from V_2 (3.08%) and lowest was recorded from V_1 (1.90%). At 72 DAS difference in disease severity on flag leaf between the varieties is statistically significant. Maximum disease severity on flag leaf was from V_2 (9.01%) and the lowest was recorded from V_1 (4.55%). At 77 DAS difference in disease severity on flag leaf between the varieties is statistically significant. maximum disease severity on flag leaf was recorded from V_2 (10.45%) and lowest was recorded from V_1 (5.69%). At 82 DAS difference in disease severity on flag leaf between the varieties is statistically significant.

maximum disease severity on flag leaf was recorded from V_2 (13.29%) and lowest was recorded from V_1 (9.01%). (Table 4.)

Table 4. Effect of varieties on disease severity on flag leaf at 67 DAS, 72 DAS, 77 DAS and 82 DAS

Variety	Disease severity(%) of flag leaf			
	At 67 DAS	At 72 DAS	At 77 DAS	At 82 DAS
V1	1.90 b	4.55 b	5.689 b	9.01 b
V2	3.08 a	9.01 a	10.45 a	13.29 a
CV	23.84	14.11	11.1	17.08
LSD	0.623	1.005	0.941	2.001

CV=Co-efficient of variance, LSD= Least Significant Difference
V_1 = BWMRI Gom -1, V_2 = BWMRI Gom -2

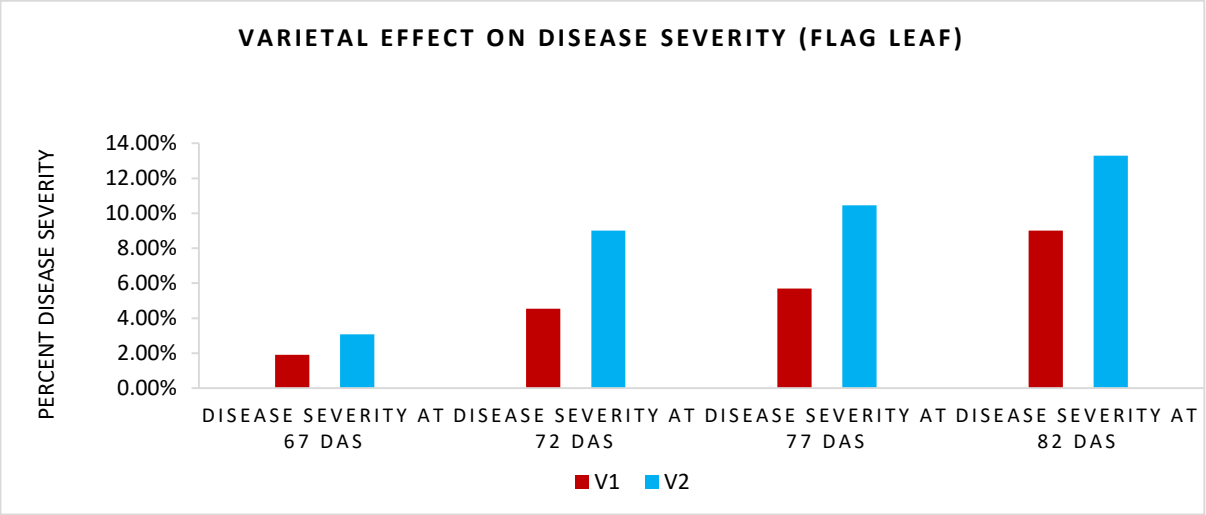


Figure 3. Effect of varieties on disease severity on flag leaf at 67 DAS, 72 DAS, 77 DAS and 82 DAS

4.1.2. Disease severity of flag-1 leaf

4.1.2.1. Interaction effect of treatment and variety on disease severity of flag-1 leaf

At 67 DAS the interaction effect of treatments and varieties varied significantly. The maximum disease severity on was obtained from T_3V_2 (4.05%) followed by T_2V_2(3.39%) T_1V_2 (3.07%), T_2V_1 (1.15%), T_3V_1 (0.87%), and the lowest disease severity was recorded from T_1 V_1 (0.00%). At 72 DAS the interaction effect varied significantly. Highest disease severity was recorded

from T_2V_2 (7.50%) followed by T_3V_2 (7.46), T_1V_2(5.51), T_2V_1 (3.23%), T_3V_1 (2.11%), and the lowest was recorded from T_1 V_1 (1.11). At 77 DAS the interaction effect of treatments and varieties varies significantly. T_2V_2 (17.49) showed the Highest disease severity followed by T_3V_2(17.16) T_1V_2 (8.22), T_3V_1 (7.55), T_21_1 (5.77) and lowest was T_1V_1 (3.72%). At 82 DAS the interaction effect of treatments and varieties varies significantly. The maximum disease severity was obtained from T_2V_2 (29.46%) followed by T_3V_2(29.40%), T_1V_2 (16.13%), T_3V_1 (15.30%), T_21_1 (9.37%) and the lowest disease severity was recorded from T_1 V_1 (5.92%). (Table 5)

Table 5. Interaction effect of treatment and variety on disease severity of flag-1 leaves at 67 DAS, 72 DAS, 77 DAS and 82 DAS

Interactions Treatment ×Variety	Disease severity(%) of flag-1 leaf			
	At 67 DAS	At 72 DAS	At 77 DAS	At 82 DAS
T_1V_1	0.00 d	1.11 d	3.72 d	5.92 d
T_2V_1	1.15 c	3.23 c	5.77 c	9.37 c
T_3V_1	0.87 c	2.11 d	7.55 b	15.30 b
T_1V_2	3.07 b	5.51 b	8.22 b	16.13 b
T_2V_2	3.39 b	7.50 a	17.49 a	29.46 a
T_3V_2	4.05 a	7.46 a	17.16 a	29.40 a
CV	14.97	12.79	7.14	7.13
LSD	0.569	1.044	1.296	2.285

CV=Co-efficient of variance, LSD= Least Significant Difference
T1 = Silicon dioxide @ 60 kg ha^{-1}, T2 = Silicon dioxide @ 120 kg ha^{-1}, T3= Silicon dioxide @ 180 kg ha^{-1}, V_1 = BWMRI Gom -1, V_2 = BWMRI Gom -2

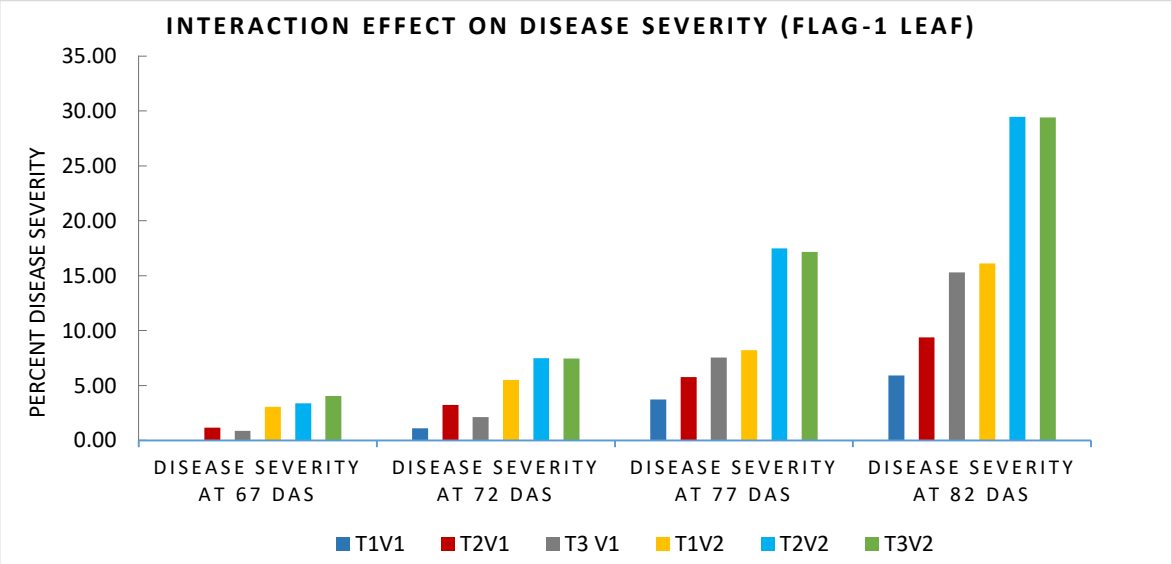


Figure 4. Interaction effect of treatment and variety on disease severity of flag-1 leaves at 67 DAS, 72 DAS, 77 DAS and 82 DAS

4.1.2.2. Effect of treatment on disease severity of flag-1 leaf

At 67 DAS effect of treatment on disease severity of flag-1 leaf varied significantly. The maximum disease severity on flag-1 leaf was obtained from T_3 (2.46%) followed by T_2 (2.27%) and the lowest disease severity was recorded from T_1 (1.54%). At 72 DAS effect of treatment on disease severity of flag-1 leaf varied significantly. The maximum disease severity on flag leaf was recorded from T_2 (5.37%) followed by T_3(4.78%) and the lowest disease severity was recorded from T_1 (3.31%). At 77 DAS effect of treatment on disease severity of flag-1 leaf varied significantly. The maximum disease severity on flag-1 leaf was recorded from T_3 (12.63%) followed by T_2(11.63) and the lowest disease severity was recorded from T_1 (5.97%). At 82 DAS effect of treatment on disease severity of flag-1 leaf varied significantly. The maximum disease severity on flag-1 leaf was recorded from T_3 (22.35%) followed by T_2(19.42%) and the lowest disease severity was recorded from T_1 (11.12%). (Table 6.)

Table 6. Effect of treatments on disease severity on flag-1 leaves at 67 DAS, 72 DAS, 77 DAS and 82 DAS

Treatments	Disease severity(%) of flag-1 leaf			
	At 67 DAS	At 72 DAS	At 77 DAS	At 82 DAS
T_1	1.54 b	3.31 b	5.97 b	11.12 b
T_2	2.27 a	5.37 a	11.63 a	19.42 a
T_3	2.46 a	4.78 a	12.63 a	22.35 a
CV	18.12	13.07	21.51	16.35
LSD	0.487	0.754	2.764	3.708

CV=Co-efficient of variance, LSD= Least Significant Difference
T1 = Silicon dioxide @ 60 kg ha^{-1}, T2 = Silicon dioxide @ 120 kg ha^{-1}, T3= Silicon dioxide @ 180 kg ha^{-1}

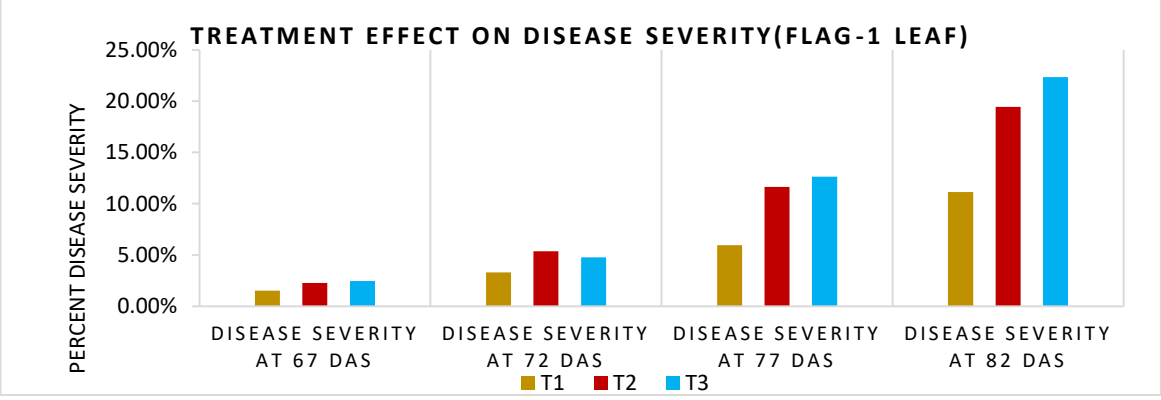


Figure 5. Effect of treatments on disease severity on flag-1 leaves at 67 DAS, 72 DAS, 77 DAS and 82 DAS

4.1.2.3. Effect of variety on disease severity of flag-1 leaf

Bipolaris blight disease severity (%) was recorded at 67DAS, 72DAS, 77 DAS and 82DAS. At 67 DAS varietal effect on disease severity of flag-1 leaf varied significantly. Maximum disease severity on flag leaf was recorded from V_2 (3.51%) and lowest was recorded from V_1 (0.67%). At 72 DAS varietal effect on disease severity of flag-1 leaf varied significantly. Maximum disease severity on flag leaf was from V_2 (6.82%) and the lowest was recorded from V_1 (2.15%). At 77 DAS varietal effect on disease severity of flag-1 leaf varied significantly. Maximum disease severity on flag leaf was recorded from V_2 (14.29%) and lowest was recorded from V_1 (5.68%). At 82 DAS varietal effect on disease severity of flag-1 leaf varied significantly. Maximum disease severity on flag leaf was recorded from V_2 (25.06%) and lowest was recorded from V_1 (10.19%). (Table 7.)

Table 7. Effect of varieties on disease severity on flag-1 leaves at 67 DAS, 72 DAS, 77 DAS and 82 DAS

Variety	Disease severity(%) of flag-1 leaf			
	At 67 DAS	At 72 DAS	At 77 DAS	At 82 DAS
V_1	0.67 b	2.15 b	5.682 b	10.19 b
V_2	3.51 a	6.82 a	14.29 a	25.06 a
CV	18.12	13.07	21.51	16.35
LSD	0.3977	0.616	2.256	3.028

CV=Co-efficient of variance, LSD= Least Significant Difference,
V_1 = BWMRI Gom -1, V_2 = BWMRI Gom -2

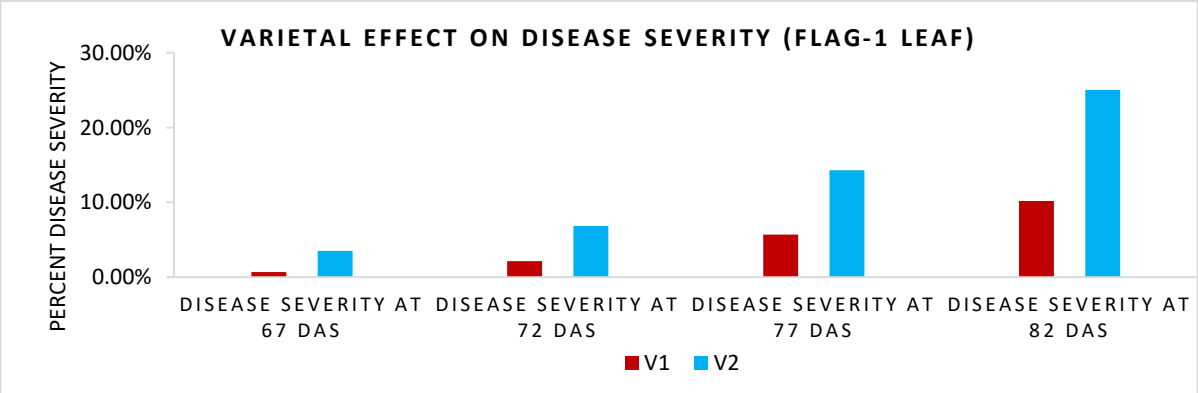


Figure 6. Effect of varieties on disease severity on flag-1 leaves at 67 DAS, 72 DAS, 77 DAS and 82 DAS

4.2. Disease Incidence

4.2.1. Disease incidence of flag leaf

4.2.1.1. Interaction effect of treatment and variety on disease incidence of flag leaf

Bipolaris blight disease incidence (%) was recorded at 67DAS, 72DAS, 77 DAS and 82DAS. At 67 DAS the interaction effect of treatments and varieties on disease incidence varies significantly. The maximum disease incidence on Flag leaf was recorded from T_2V_2 (28.89%) followed by T_3V_2(24.44%), T_1V_2(22.22%), T_2V_1(17.77%) and the lowest disease incidence on flag leaf was recorded from T_3V_1(13.33%) and T_1V_1(13.33%). At 72 DAS the interaction effect of treatments and varieties on disease incidence varies significantly. The highest disease incidence on flag leaf was recorded from T_2V_2(57.77%) followed by T_2V_2(44.44%), T_1V_1 (44.44%), T_2V_1 (40%), and the lowest was recorded from T_2V_1 (33.33%) & T_311 (33.33%). At 77 DAS the interaction effect of treatments and varieties on disease incidence varies significantly. T_2V_2 (66.70%) showed the Highest disease incidence followed by T_3V_2(57.78%), T_1V_2 (53.34%), T_1V_1 (44.44%), T_311 (42.33%) and lowest was T_2V_1 (37.78%). At 82 DAS the interaction effect of treatments and varieties on disease incidence varies significantly. Maximum disease incidence (%) on flag leaf was recorded in T_2V_2 (77.77%) & T_3V_2(77.77%) followed by, T_1V_1 (62.62%), T_1V_2 (53.33%), T_3V_1 (51.11%) and the lowest Disease incidence (%) on flag leaf was recorded from T_2V_1 (44.44%). (Table 8.)

Table 8. Interaction effect of treatment and varieties on disease incidence on flag leaf at 67 DAS, 72 DAS, 77 DAS and 82 DAS

Interactions Treatment × Variety	Disease incidence(%) for flag leaf			
	At 67 DAS	At 72 DAS	At 77 DAS	At 82 DAS
T_1V_1	13.33 d	44.44 b	44.44 bcd	62.22 b
T_2V_1	17.77 cd	33.33 b	37.78 d	44.44 c
T_3V_1	13.33 d	33.33 b	42.23 cd	51.11 c
T_1V_2	22.22 bc	40.00 b	53.34 abc	53.33 bc
T_2V_2	28.89 a	57.77 a	66.70 a	77.77 a
T_3V_2	24.44 ab	44.44 b	57.78 ab	77.77 a
CV	16.10	17.06	15.22	9.13
LSD	5.859	13.101	13.95	10.148

CV=Co-efficient of variance
LSD= Least Significant Difference
T1 = Silicon dioxide @ 60 kg ha^{-1}
T2 = Silicon dioxide @ 120 kg ha^{-1}
T3= Silicon dioxide @ 180 kg ha^{-1}
V_1 = BWMRI Gom -1
V_2 = BWMRI Gom -2

4.2.1.2. Effect of treatment on disease incidence of flag leaf

Bipolaris blight disease incidence (%) was recorded at 67DAS, 72DAS, 77 DAS and 82DAS. At 67 DAS treatment effect on disease incidence (%)of flag leaf was varied significantly. The maximum disease incidence (%) on flag leaf was obtained from T_2 (23.33%) followed by T_3 (18.89%) and the lowest disease incidence (%) was recorded from T_1 (17.78%). At 72 DAS treatment effect on disease incidence (%) of flag leaf was not varied significantly. The maximum disease incidence (%) on flag leaf was recorded from T_2 (45.55%) followed by T_1(42.22) and the lowest disease incidence (%) was recorded from T_3 (38.89%). At 77 DAS treatment effect on disease incidence (%) of Flag leaf was not varied significantly. The maximum disease incidence (%) on Flag leaf was obtained from T_2 (52%) followed by T_3(8.62%) and the lowest disease incidence (%) was recorded from T_1 (48.89%). At 82 DAS treatment effect on disease incidence (%) of flag leaf was not varied significantly. The maximum disease incidence (%)on flag leaf was obtained from T_3 (64.44%) followed by T_2(61.11%) and the lowest disease incidence (%) was recorded from T_1 (57.78%). (Table 9.)

Table 9. Effect of treatment on disease incidence of flag leaf at 67 DAS, 72 DAS, 77 DAS and 82 DAS

Treatments	Disease incidence(%) of flag leaf			
	At 67 DAS	At 72 DAS	At 77 DAS	At 82 DAS
T_1	17.78 b	42.22 a	48.89 a	57.78 a
T_2	23.33 a	45.55 a	52.22 a	61.11 a
T_3	18.89 b	38.89 a	50.00 a	64.44 a
CV	13.61	24.97	18.67	21.73
LSD	3.501	13.56	12.096	17.082

CV=Co-efficient of variance
LSD= Least Significant Difference
T1 = Silicon dioxide @ 60 kg ha^{-1}
T2 = Silicon dioxide @ 120 kg ha^{-1}
T3= Silicon dioxide @ 180 kg ha^{-1}

4.2.1.3. Effect of variety on disease incidence of flag leaf

Bipolaris blight disease incidence (%) was recorded at 67 DAS, 72 DAS, 77 DAS and 82DAS. At 67 DAS difference in disease incidence (%) on flag leaf between the varieties is statistically significant. Maximum disease incidence (%) on flag leaf was recorded from V_2 (25.187%) and lowest was recorded from V_1 (14.812%). At 72 DAS difference in disease incidence (%) on

flag leaf between the varieties is statistically significant. Maximum disease incidence (%) on flag leaf was from V_2 (47.41%) and the lowest was recorded from V_1 (37.03%). At 77 DAS difference in disease incidence (%) on flag leaf between the varieties is statistically significant. Maximum disease incidence (%) on flag leaf was recorded from V_2 (59.26%) and lowest was recorded from V_1 (41.48%). At 82 DAS difference in disease incidence (%) on flag leaf between the varieties is statistically significant. Maximum disease incidence (%) on flag leaf was recorded from V_2 (69.62%) and lowest was recorded from V_1 (52.59%). (Table 10.)

Table 10. Varietal effect on disease incidence on flag leaf at 67 DAS, 72 DAS, 77 DAS AND 82 DAS

Variety	Disease incidence(%) of flag leaf			
	At 67 DAS	At 72 DAS	At 77 DAS	At 82 DAS
V_1	14.812 b	37.03 a	41.48 b	52.59 b
V_2	25.187 a	47.41 a	59.26 a	69.62 a
CV	13.61	24.97	18.67	21.73
LSD	2.859	11.072	9.877	13.947

CV=Co-efficient of variance
LSD= Least Significant Difference
V_1 = BWMRI Gom -1
V_2 = BWMRI Gom -2

4.2.2. Disease incidence of flag-1 leaf

4.2.2.1. Interaction effect of treatment and variety on disease incidence of flag-1 leaf

At 67 DAS the interaction effect of treatments and varieties varies significantly. The maximum disease incidence (%) on flag leaf-1 was obtained from T_2V_2 (37.78%) followed by T_3V_2(31.11%), T_1V_2 (20%), T_2V_1 (17.78%), and the lowest disease incidence (%) on flag-1 leaf was recorded from T_3V_1 (0.00%) & T_1V_1 (0.00%). At 72 DAS the interaction effect of treatments and varieties varies significantly. Highest disease incidence (%) on flag-1 leaf was recorded from T_2V_2 (44.44%) followed by T_1V_2 (40%), T_3V_2(5.51%), T_2V_1 (33.33%), T_3V_1 (22.0%), and the lowest was recorded from T_1V_1 (8.89%). At 77 DAS the interaction effect of treatments and varieties varies significantly. T_2V_2 (91.11%) showed the highest disease incidence (%) followed by T_3V_2(66.67%), T_1V_2 (48.89), T_3V_1 (44.45%), T_21_1 (42.22%) and lowest was T_1V_1

(35.55%). At 82 DAS the interaction effect of treatments and varieties varies significantly. The maximum. disease incidence (%) on flag-1 leaf was obtained from T_2V_2 (95.55%) followed by T_3V_2(88.89%), T_3V_1 (71.11%), T_1V_2 (62.22%), T_2V_1 (48.89%) and the lowest disease incidence (%) on flag-1 leaf was recorded from T_1 V_1 (35.55%). (Table 11.)

Table 11. Effect of interactions on disease incidence on flag-1 leaves at 67 DAS, 72 DAS, 77 DAS AND 82 DAS

Interactions (Treatment × Variety)	Disease incidence(%) for flag-1 leaf			
	At 67 DAS	At 72 DAS	At 77 DAS	At 82 DAS
T_1V_1	0.00 d	8.89 d	35.55 d	35.55 d
T_2V_1	17.78 c	33.33 b	42.22 cd	48.89 c
T_3V_1	0.00 d	22.00 c	44.45 cd	71.11 b
T_1V_2	20.00 bc	40.00 ab	48.89 c	62.22 b
T_2V_2	37.78 a	44.44 a	91.11 a	95.55 a
T_3V_2	31.11 ab	35.55 b	66.67 b	88.89 a
CV	36.87	15.56	10.34	9.89
LSD	11.92	8.694	10.308	12.062

CV=Co-efficient of variance, LSD= Least Significant Difference, T1 = Silicon dioxide @ 60 kg ha^{-1}, T2 = Silicon dioxide @ 120 kg ha^{-1}, T3= Silicon dioxide @ 180 kg ha^{-1}, V_1 = BWMRI Gom -1, V_2 = BWMRI Gom -2

4.2.2.2. Effect of treatment on disease incidence of flag leaf-1

At 67 DAS effect of treatment on disease incidence (%) of Flag-1 leaf varied significantly. The maximum disease incidence (%) on flag-1 leaf was obtained from T_2 (27.78%) followed by T_3 (15.56%) and the lowest disease incidence (%) was recorded from T_1 (9.99%). At 72 DAS effect of treatment on disease incidence (%) of flag-1 leaf varied significantly. The maximum disease incidence (%) on flag leaf was recorded from T_2 (38.89%) followed by T_3(28.78%) and the lowest disease incidence (%) was recorded from T_1 (24.45%). At 77 DAS effect of treatment on disease incidence (%) of flag-1 leaf varied significantly. The maximum disease incidence (%) on flag-1 leaf was recorded from T_2 (66.67%) followed by T_3(55.56%) and the lowest disease incidence (%)was recorded from T_1 (42.22%). At 82 DAS effect of treatment on disease incidence (%) of flag-1 leaf varied significantly. The maximum disease incidence (%)on flag-1 leaf was recorded from T_3 (80.0%) followed by T_2(72.22%) and the lowest disease incidence (%) was recorded from T_1 (48.9%). (Table 12.)

Table 12. Effect of treatment on disease incidence of flag-1 leaves at 67 DAS, 72 DAS, 77 DAS and 82 DAS

Treatments	Disease incidence(%) Of flag-1 leaf			
	At 67 DAS	At 72 DAS	At 77 DAS	At 82 DAS
T_1	9.99 b	24.45 b	42.22 b	48.89 b
T_2	27.78 a	38.89 a	66.67 a	72.22 a
T_3	15.56 b	28.78 b	55.56 ab	80.00 a
CV	40.5	24.22	20.67	14.93
LSD	9.262	9.565	14.576	12.878

CV=Co-efficient of variance, LSD= Least Significant Difference, T1 = Silicon dioxide @ 60 kg ha^{-1}, T2 = Silicon dioxide @ 120 kg ha^{-1}, T3= Silicon dioxide @ 180 kg ha^{-1}

4.2.2.3. Effect of variety on disease incidence of flag-1 leaf

Bipolaris blight disease incidence (%)was recorded at 67DAS, 72DAS, 77 DAS and 82DAS. At 67 DAS varietal effect on disease incidence (%)of flag-1 leaf varied significantly. Maximum disease incidence (%) on Flag-1 leaf was recorded from V_2 (29.63%) and lowest was recorded from V_1 (5.92%). At 72 DAS varietal effect on disease incidence (%)of flag-1 leaf varied significantly. Maximum disease incidence (%)on Flag leaf was from V_2 (40%) and the lowest was recorded from V_1 (21.41%). At 77 DAS varietal effect on disease incidence (%) of flag-1 leaf varied significantly. Maximum disease incidence (%) on flag-1 leaf was recorded from V_2 (68.89%) and lowest was recorded from V_1 (40.74%). At 82 DAS varietal effect on disease incidence (%) of flag-1 leaf varied significantly. Maximum disease incidence (%) on flag leaf was recorded from V_2 (82.22%) and lowest was recorded from V_1 (51.85%). (Table 13.)

Table 13. Varietal effect on disease incidence of flag-1 leaves at 67 DAS, 72 DAS, 77 DAS and 82 DAS

Variety	Disease incidence(%) of flag-1 leaf			
	At 67 DAS	At 72 DAS	At 77 DAS	At 82 DAS
V_1	5.92 b	21.41b	40.74 b	51.85 b
V_2	29.63 a	40.00 a	68.89 a	82.22 a
CV	40.5	24.22	20.67	14.93
LSD	7.563	7.809	11.901	10.51

CV=Co-efficient of variance
LSD= Least Significant Difference
V_1 = BWMRI Gom -1
V_2 = BWMRI Gom -2

4.3. Seed health test (Blotter method)

Seeds collected from different treated plot were subjected to test germination and test health of seeds after the harvesting (Figure 7).

Figure 7(a). Seeds on blotter paper in petri plates

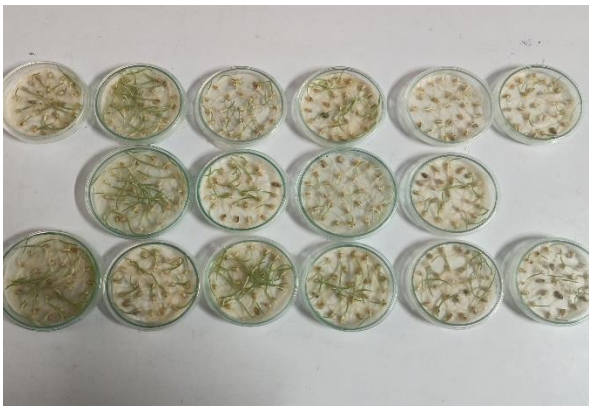


Figure 7(b). Seed germination at 4th day

Figure 7(c). Seed germination with no pathogen attack

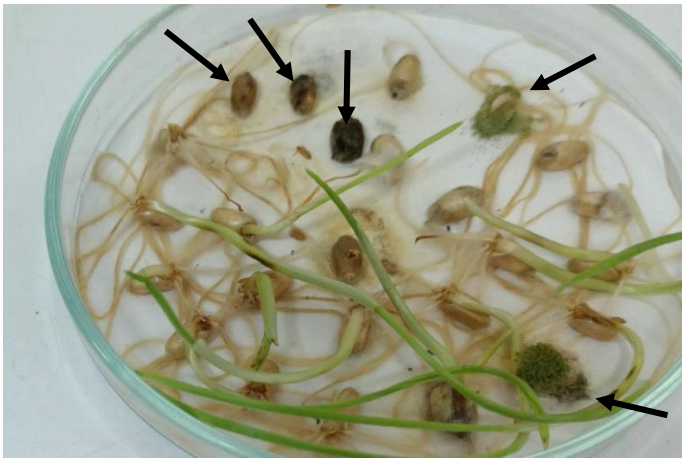


Figure 7(d). Seed germination with several pathogen attack

4.3.1. Germination test

Data were recorded on percent normal seedlings, percent abnormal seedlings, percent total seed germination and percent dead seed.

4.3.1.1. Interaction effect of treatment and variety on germination test

Interaction effect of treatments and varieties on normal seedling varied significantly. The maximum normal seedling was recorded from T_1V_1 (97.58%) followed by T_2V_1(95.0%), T_1V_2(95.0%), T_3V_1(92.75%), T_2V_2(90.75%) and the lowest normal seedling was recorded from T_3V_2(88.5%). The interaction effect of treatments and varieties on abnormal seedling varied significantly. The highest abnormal seedling was recorded from T_3V_2(6.75%) followed by T_2V_2(5.67%), T_3V_1 (4.25%), T_2V_1 (3.25%) T_1 V_2 (3.0%), and the lowest was recorded from T_11_1 (1.50%). The interaction effect of treatments and varieties on total germination varied significantly. T_1V_1 (99.08%) showed the highest total germination followed by T_2V_1(98.25%), T_1V_2 (98.0%), T_3V_1 (97.0%), T_2V_2 (96.42%) and lowest was T_3V_2 (95.25%). The interaction effect of treatments and varieties on dead seed number varied significantly. Maximum dead seed number was recorded in T_3V_2 (4.75%) followed by, T_2V_2(3.58%), T_3V_1(3.0%), T_1V_2 (2.0%), T_2V_1 (1.75%) and the lowest dead seed number was recorded from T_1V_1 (0.92%). (Table 14.)

Table 14. Interaction effect of treatment and variety on percent normal seedlings, percent abnormal seedlings, percent total seed germination and percent dead seed

Interaction Treatment × Variety	Normal seedlings (%)	Abnormal seedlings (%)	Total Seed Germination (%)	Dead seed (%)
T_1V_1	97.58 a	1.50 e	99.08 a	0.92 d
T_2V_1	95.00 b	3.25 d	98.25 b	1.75 c
T_3V_1	92.75 c	4.25 c	97.00 c	3.00 b
T_1V_2	95.00 b	3.00 d	98.00 b	2.00 c
T_2V_2	90.75 d	5.67 b	96.42 c	3.58 b
T_3V_2	88.50 e	6.75 a	95.25 d	4.75 a
CV	0.63	11.31	0.37	13.37
LSD	1.069	0.837	0.649	0.649

Values having same letter within a column do not differ significantly at 5% level of probability, CV=Co-efficient of variance, LSD= Least Significant Difference, T1 = Silicon dioxide @ 60 kg ha^{-1}, T2 = Silicon dioxide @ 120 kg ha^{-1}, T3= Silicon dioxide @ 180 kg ha^{-1}, V_1 = BWMRI Gom -1, V_2 = BWMRI Gom -2

4.3.1.2. Treatment effect on seed health

The result revealed that the maximum normal seedling was obtained from T_1 (96.29%) followed by T_2 (92.88%). The lowest normal seedling number was recorded in T_3 (90.63%). Maximum abnormal seedling was obtained from T_3 (5.50%) followed by T_2 (4.46%). The lowest normal seedling number was recorded in T_1 (2.25%). Maximum total seed germination was obtained from T_1 (98.54%) followed by T_2 (97.33%). The lowest normal seedling number was recorded in T_3 (96.13%). Maximum dead seed number obtained from T_3 (3.88%) followed by T_2 (2.67%). The lowest normal seedling number was recorded in T_1 (1.46%). (Table 15.)

Table 15. Effect of treatment on percent normal seedlings, percent abnormal seedlings, percent total seed germination and percent dead seed

Treatment (T)	Normal seedlings (%)	Abnormal seedlings (%)	Total Seed Germination (%)	Dead seed (%)
T_1	96.29 a	2.25 c	98.54 a	1.46 c
T_2	92.88 b	4.46 b	97.33 b	2.67 b
T_3	90.63 c	5.50 a	96.13 c	3.88 a
CV	0.63	11.31	0.37	13.37
LSD	0.756	0.592	0.459	0.459

Values having same letter within a column do not differ significantly at 5% level of probability
CV=Co-efficient of variance
LSD= Least Significant Difference
T1 = Silicon dioxide @ 60 kg ha^{-1}
T2 = Silicon dioxide @ 120 kg ha^{-1}
T3= Silicon dioxide @ 180 kg ha^{-1}

4.3.1.3. Variety effect on seed health

Normal seedling was recorded in V_1 (95.11%) as the highest, on the other hand, V_2 (91.42%) was the lowest. Abnormal seedling was recorded in V_2 (5.14%) as the highest and V_1 (3.0%) was the lowest. Total seed germination was recorded in V_1 (98.11%) as the highest, on the other hand, V_2 (96.56%) showed the lowest germination. Dead seed number was recorded in V_2 (3.44%) as the maximum, on the other hand V_1 (1.89%) showed the minimum. (Table 16.)

Table 16. Effect of variety on percent normal seedlings, percent abnormal seedlings, percent total seed germination and percent dead seed

Variety (V)	Normal seedlings (%)	Abnormal seedlings (%)	Total Seed Germination (%)	Dead seed (%)
V_1	95.11 a	3.00 b	98.11 a	1.89 b
V_2	91.42 b	5.14 a	96.56 b	3.44 a
CV	0.63	11.31	0.37	13.37
LSD	0.617	0.483	0.374	0.374

Values having same letter within a column do not differ significantly at 5% level of probability
CV=Co-efficient of variance
LSD= Least Significant Difference
V_1 = BWMRI Gom -1
V_2 = BWMRI Gom -2

4.3.2. Pathogens (%) associated with wheat seed

4.3.2.1. Interaction effect of treatment and variety on pathogen associated with wheat seed

Interaction effect of treatments and varieties on wheat seed associated with *Bipolaris sorokiniana* pathogen varied significantly. The maximum seed associated with *Bipolaris sorokiniana* was recorded from T_3V_2 (17.66%) followed by T_3V_1(15.33%), T_2V_2(14.58%), T_1V_2(12.08%), T_2V_1(9.25%) and the lowest infected seed was recorded from T_1V_1(8.18%). The interaction effect of treatments and varieties on wheat seed associated with *Fusarium* pathogen varied significantly. The highest number of seed associated with *Fusarium* sp. pathogen was recorded from T_3V_2(12%) followed by T_2V_2(9.42%), T_3V_1 (7.83%), T_1V_2 (6.58%), T_2V_1 (3.92%), and the lowest was recorded from T_1V_1 (2.75%). The interaction effect of treatments and varieties on wheat seed associated with *Aspergillus* pathogen varied significantly. T_3V_1 (11.58%) showed the highest number of seed associated with followed by T_2V_2(7.25%), T_1V_2 (5.16%), T_3V_2 (2.83%), T_2V_1 (2.33%) and lowest was T_1V_1 (1.58%). The interaction effect of treatments and varieties on wheat seed associated with *Curvularia* varied significantly. Maximum number of seed associated with *Curvularia* was recorded in T_1V_2 (7.75%) followed by, T_3V_2(5.92%), T_3V_1(5.75%), T_2V_1 (5.25%), T_1V_1 (4.50%) and the lowest dead seed number was recorded from T_2V_2 (3.17%). The interaction effect of treatments and varieties on wheat seed associated with *Colletotrichum* varied significantly. Maximum number of seed associated with *Colletotrichum* was recorded in T_3V_2 (2.83%) followed by T_1V_2(2.0%), T_2V_1(1.50%), T_1V_1 (0.33%), and the lowest dead seed number was recorded from T_2V_2 (0.0%) & T_1V_1 (0.0%). (Table 17.)

Table 17. Interaction effect of treatment and variety on pathogenic fungi associated with wheat seed

Interaction Treatment × Variety	Pathogens(%) associated with wheat seed				
	Bipolaris	*Fusarium*	*Aspergillus*	*Curvularia*	*Colletotrichum*
T_1V_1	8.18 d	2.75 d	1.58 d	4.50 bc	0.33 c
T_2V_1	9.25 d	3.92 d	2.33 d	5.25 bc	1.50 b
T_3V_1	15.33 b	7.83 c	11.58 a	5.75 ab	0.00 c
T_1V_2	12.08 c	6.58 c	5.16 c	7.75 a	2.00 b
T_2V_2	14.58 b	9.42 b	7.25 b	3.17 c	0.00 c
T_3V_2	17.66 a	12.00 a	2.83 d	5.92 ab	2.83 a
CV	7.33	10.8	14.63	22.02	28.95
LSD	1.713	1.392	1.365	2.159	0.585

Values having same letter within a column do not differ significantly at 5% level of probability

CV=Co-efficient of variance
LSD= Least Significant Difference
T1 = Silicon dioxide @ 60 kg ha^{-1}, T2 = Silicon dioxide @ 120 kg ha^{-1}, T3= Silicon dioxide @ 180 kg ha^{-1}
V_1 = BWMRI Gom -1, V_2 = BWMRI Gom -2

4.3.2.2. Effect of treatment on pathogen associated with wheat seed

Effect of treatments on wheat seed associated with *Bipolaris sorokiniana* pathogen varied significantly. The maximum seed associated with *Bipolaris sorokiniana* was recorded from T_3 (16.50%) followed by T_2 (11.92%) and the lowest infected seed was recorded from T_1(10.13%). Effect of treatments on wheat seed associated with *Fusarium* sp. pathogen varied significantly. The highest number of seed associated with *Fusarium* sp. pathogen was recorded from T_3 (9.91%) followed by T_2 (6.67%) and the lowest was recorded from T_1 (4.67%). Effect of treatments on wheat seed associated with *Aspergillus* sp. pathogen varied significantly. T_3 (7.21%) showed the Highest number of seed associated with *Aspergillus* sp. followed by T_2 (4.79%) and lowest was T_1 (3.38%). Effect of treatments on wheat seed associated with *Curvularia* sp. varied significantly. Maximum number of seed associated with *Curvularia* sp. was recorded in T_1 (6.13%) followed by, T_3 (5.83%) and the lowest dead seed number was recorded from T_2 (4.21%). Effect of treatments on wheat seed associated with *Colletotrichum* sp. varied significantly. Maximum number of seed associated with *Colletotrichum* sp. was recorded in T_3 (1.42%) followed by T_1 (1.17%) and the lowest dead seed number was recorded from T_2 (0.75%). (Table 18.)

Table 18. Effect of treatment on pathogenic fungi associated with wheat seed

Treatment (T)	**Pathogens(%) associated with wheat seed**				
	Bipolaris	*Fusarium*	*Aspergillus*	*Curvularia*	*Colletotrichum*
T_1	10.13 c	4.67 c	3.38 c	6.13 a	1.17 a
T_2	11.92 b	6.67 b	4.79 b	4.21 b	0..75 b
T_3	16.50 a	9.91 a	7.21 a	5.83 a	1.42 a
CV	7.33	10.8	14.63	22.02	28.95
LSD	1.212	0.984	0.965	1.526	0.414

Values having same letter within a column do not differ significantly at 5% level of probability
CV=Co-efficient of variance
LSD= Least Significant Difference
T1 = Silicon dioxide @ 60 kg ha^{-1}, T2 = Silicon dioxide @ 120 kg ha^{-1}, T3= Silicon dioxide @ 180 kg ha^{-1}

4.3.2.3 Effect of variety on pathogen associated with wheat seed

Varietal effect on wheat seed associated with *Bipolaris sorokiniana* pathogen varied significantly. The maximum seed associated with *Bipolaris sorokiniana* was recorded from V_2 (14.78%) and the lowest infected seed was recorded from V_1 (10.92%). Varietal effect on wheat seed associated with *Fusarium* sp. pathogen varied significantly. The highest number of seed associated with *Fusarium* sp. pathogen was recorded from V_2 (9.33%) and the lowest was recorded from V_1 (4.83%). Varietal effect on wheat seed associated with *Aspergillus* sp. pathogen was not varied significantly. V_1 (5.17%) showed the Highest number of seed associated with *Aspergillus* sp. and lowest was V_2 (5.08%). Varietal effect on wheat seed associated with *Curvularia* sp. was not varied significantly. Maximum number of seed associated with *Curvularia* sp. was recorded in V_2 (5.61%) and the lowest dead seed number was recorded from V_1 (5.17%). Varietal effect on wheat seed associated with *Colletotrichum* sp. varied significantly. Maximum number of seed associated with *Colletotrichum* sp. was recorded in V_2 (1.61%) and the lowest dead seed number was recorded from V_1 (0.61%). (Table 19.)

Table 19. Effect of Variety on pathogenic fungi associated with wheat seed

Variety (V)	Pathogens(%) associated with wheat seed				
	Bipolaris	*Fusarium*	*Aspergillus*	*Curvularia*	*Colletotrichum*
V_1	10.92 b	4.83 b	5.17 a	5.17 a	0.61 b
V_2	14.78 a	9.33 a	5.08 a	5.61 a	1.61 a
CV	7.33	10.8	14.63	22.02	28.95
LSD	0.989	0.804	0.788	1.246	0.338

Values having same letter within a column do not differ significantly at 5% level of probability
CV=Co-efficient of variance, LSD= Least Significant Difference, V_1 = BWMRI Gom-1, V_2 = BWMRI Gom-2

4.4. Plant Height

4.4.1. Interaction effect of treatment and variety on plant height

At 67 DAS interaction effect of treatments and varieties on plant height among the varieties varied significantly. The maximum Plant Height was recorded from T_1V_1 (81.16cm) followed by T_2V_1(80.80cm), T_3V_1(80.40cm), T_2V_2(77.91cm), T_1V_2(73.53cm) and the lowest Plant Height was recorded from T_3V_2(71.71 cm). At 72 DAS the interaction effect of treatments and varieties on plant height was not varied significantly. The highest Plant Height was recorded from T_2V_2(85.54cm) followed by T_1V_1(85.42 cm), T_2V_1 (84.87 cm), T_3V_1 (84.62 cm), T_1V_2 (81.16cm), and the lowest was recorded from T_3V_2 (79.24 cm). At 77 DAS the interaction effect of treatments and varieties on plant height was not varied significantly. T_2V_2 (88.96cm) showed the Highest Plant Height followed by T_1V_2(88.89), T_1V_1 (88.58cm), T_3V_1 (88.25cm), T_1V_2 (85.89cm) and lowest was T_3V_2 (83.78cm). At 82 DAS the interaction effect of treatments and varieties on plant height was not varied significantly. Maximum plant height was recorded in T_2V_2 (90.89cm) followed by, T_1V_1(90.49cm), T_3V_1(89.93%), T_2V_1 (88.67cm), T_1V_2 (87.62cm) and the lowest plant height was recorded from T_3V_2 (86.11cm). (Table 20.)

Table 20. Interaction effect of treatment and variety on plant height at 67DAS, 72DAS, 77DAS and 82 DAS

Treatments	Plant height (cm)			
	At 67 DAS	At 72 DAS	At 77 DAS	At 82 DAS
T_1V_1	81.16 a	85.42 a	88.58 a	90.49 a
T_2V_1	80.80 a	84.87 a	87.04 a	88.67 a
T_3V_1	80.40 a	84.62 a	88.25 a	89.93 a
T_1V_2	73.53 b	81.16 a	85.89 a	87.62 a
T_2V_2	77.91 ab	85.54 a	88.96 a	90.89 a
T_3V_2	71.71 b	79.24 a	83.78 a	86.11 a
CV	4.82	4.79	4.38	4.09
LSD	6.809	7.272	6.946	6.618

Values having same letter within a column do not differ significantly at 5% level of probability

CV=Co-efficient of variance
LSD= Least Significant Difference
T1 = Silicon dioxide @ 60 kg ha^{-1}, T2 = Silicon dioxide @ 120 kg ha^{-1}, T3= Silicon dioxide @ 180 kg ha^{-1}
V_1 = BWMRI Gom -1, V_2 = BWMRI Gom -2

4.4.2. Effect of treatment on plant height

At 67 DAS effect of treatment on plant height among the varieties was not varied significantly. The maximum Plant Height was recorded from T_2 (79.36cm) followed by T_1 (77.34cm) and the lowest Plant Height was recorded from T_3 (76.06cm). At 72 DAS effect of treatment on plant height was not varied significantly. The highest plant height was recorded from T_2 (85.20cm) followed by T_1 (83.29cm), and the lowest was recorded from T_3 (86.01cm). At 77 DAS effect of treatment on plant height was not varied significantly. T_2 (88.0cm) showed the highest plant height followed by T_1 (87.23cm) and lowest was T_3 (86.01cm). At 82 DAS effect of treatment on plant height was not varied significantly. Maximum plant height was recorded in T_2 (89.78cm) followed by T_1 (89.05cm) and the lowest plant height was recorded from T_3 (88.02cm). (Table 21.)

Table 21. Effect of treatment on plant height at 67DAS, 72DAS, 77DAS and 82 DAS

Treatments	Plant height (cm)			
	At 67 DAS	At 72 DAS	At 77 DAS	At 82 DAS
T_1	77.34 a	83.29 a	87.23 a	89.05 a
T_2	79.36 a	85.20 a	88.00 a	89.78 a
T_3	76.06 a	81.93 a	86.01 a	88.02 a
CV	4.82	4.79	4.38	4.09
LSD	4.814	5.142	4.912	4.679

Values having same letter within a column do not differ significantly at 5% level of probability
CV=Co-efficient of variance
LSD= Least Significant Difference
T1 = Silicon dioxide @ 60 kg ha^{-1}, T2 = Silicon dioxide @ 120 kg ha^{-1}, T3= Silicon dioxide @ 180 kg ha^{-1}

4.4.3. Effect of variety on plant height

At 67 DAS varietal effect on plant height among the varieties varied significantly. The maximum plant height was recorded from V_1 (80.79cm) and the lowest plant height was recorded from V_2 (74.38cm). At 72 DAS varietal effect on plant height was not varied significantly. The highest plant height was recorded from V_1 (84.97cm) and the lowest was recorded from V_2 (81.98cm). At 77 DAS varietal effect on plant height was not varied significantly. V_1 (87.96cm) showed the highest plant height and lowest was V_2 (86.21cm). At 82 DAS varietal effect on plant height was not varied significantly. Maximum plant height was recorded in V_1 (89.70cm) and the lowest plant height was recorded from V_2 (88.21cm). (Table 22.)

Table 22. Effect of variety on plant height at 67DAS, 72DAS, 77DAS and 82 DAS

Variety	Plant height (cm)			
	At 67 DAS	At 72 DAS	At 77 DAS	At 82 DAS
V_1	80.79 a	84.97 a	87.96 a	89.70 a
V_2	74.38 b	81.98 a	86.21 a	88.21 a
CV	4.82	4.79	4.38	4.09
LSD	3.931	4.198	4.01	3.821

Values having same letter within a column do not differ significantly at 5% level of probability
CV=Co-efficient of variance, LSD= Least Significant Difference
V_1 = BWMRI Gom -1,
V_2 = BWMRI Gom -2

4.5. Spike Length

4.5.1. Interaction effect of treatment and variety on spike length

At 67 DAS interaction effect of treatments and varieties on spike length among the varieties varied significantly. The maximum spike length was recorded from T_2V_2 (10.09cm) followed by T_1V_2(9.22cm), T_1V_1(8.51cm), T_3V_2(8.23cm), T_2V_1(7.61cm) and the lowest spike length was recorded from T_3V_1(7.13 cm). At 72 DAS the interaction effect of treatments and varieties on spike length varied significantly. The highest spike length was recorded from T_2V_2(12.24cm) followed by T_3V_2(11.56 cm), T_1V_2 (10.76 cm), T_1V_1 (10.69 cm), T_2 V_1 (10.26cm), and the lowest was recorded from T_3V_1 (10.19 cm). At 77 DAS the interaction effect of treatments and varieties on spike length was not varied significantly. T_2V_2 (12.39cm) showed the highest spike length followed by T_3V_2(11.73cm), T_1V_2 (10.95cm), T_1V_1 (10.86cm), T_2V_1 (10.44cm) and lowest was T_3V_1 (10.33cm). At 82 DAS the interaction effect of treatments and varieties on spike length was not varied significantly. Maximum spike length was recorded in T_2V_2 (12.61cm) followed by, T_3V_2(11.96cm), T_1V_2(11.19cm), T_1V_1 (11.02cm), T_2V_1 (10.59cm) and the lowest spike length was recorded from T_3V_1 (10.49cm). (Table 23.)

Table 23. Interaction effect of treatment and variety on spike length at 67DAS, 72DAS, 77DAS and 82 DAS

Treatments	Spike length (cm)			
	At 67 DAS	At 72 DAS	At 77 DAS	At 82 DAS
T_1V_1	8.51 bc	10.69 bc	10.86 bc	11.02 bc
T_2V_1	7.61 cd	10.26 c	10.44 c	10.59 c
T_3V_1	7.13 d	10.19 c	10.33 c	10.49 c
T_1V_2	9.22 ab	10.76 bc	10.95 bc	11.19 bc
T_2V_2	10.09 a	12.24 a	12.39 a	12.61 a
T_3V_2	8.23 bcd	11.56 ab	11.73 ab	11.96 ab
CV	8.48	6.33	6.24	6.12
LSD	1.306	1.262	1.262	1.259

Values having same letter within a column do not differ significantly at 5% level of probability

CV=Co-efficient of variance, LSD= Least Significant Difference, T1 = Silicon dioxide @ 60 kg ha^{-1}, T2 = Silicon dioxide @ 120 kg ha^{-1}, T3= Silicon dioxide @ 180 kg ha^{-1}, V_1 = BWMRI Gom -1, V_2 = BWMRI Gom -2

4.5.2. Effect of treatment on spike length

At 67 DAS effect of treatment on spike length among the varieties varied significantly. The maximum spike length was recorded from T_1 (8.87cm) followed by T_2 (8.85cm) and the lowest spike length was recorded from T_3 (7.68cm). At 72 DAS effect of treatment on spike length was not varied significantly. The highest spike length was recorded from T_2 (11.25cm) followed by T_3 (10.88cm), and the lowest was recorded from T_1 (10.73cm). At 77 DAS effect of treatment on spike length was not varied significantly. T_2 (11.41cm) showed the highest spike length followed by T_3 (11.03cm) and lowest was T_1 (10.90cm). At 82 DAS effect of treatment on spike length was not varied significantly. Maximum spike length was recorded in T_2 (11.60cm) followed by T_3 (11.23cm) and the lowest spike length was recorded from T_1 (11.11cm). (Table 24.)

Table 24. Effect of treatment on spike length at 67DAS, 72DAS, 77DAS and 82 DAS

Treatments	Spike length (cm)			
	At 67 DAS	At 72 DAS	At 77 DAS	At 82 DAS
T_1	8.87 a	10.73 a	10.90 a	11.11 a
T_2	8.85 a	11.25 a	11.41 a	11.60 a
T_3	7.68 b	10.88 a	11.03 a	11.23 a
CV	8.48	6.33	6.24	6.12
LSD	0.923	0.893	0.893	0.89

Values having same letter within a column do not differ significantly at 5% level of probability
CV=Co-efficient of variance, LSD= Least Significant Difference
T1 = Silicon dioxide @ 60 kg ha^{-1}, T2 = Silicon dioxide @ 120 kg ha^{-1}, T3= Silicon dioxide @ 180 kg ha^{-1}

4.5.3. Effect of variety on spike length

At 67 DAS varietal effect on spike length among the varieties varied significantly. The maximum spike length was recorded from V_2 (9.18cm) and the lowest spike length was recorded from V_1 (7.75cm). At 72 DAS varietal effect on spike length varied significantly. The highest spike length was recorded from V_2 (11.52cm) and the lowest was recorded from V_1 (10.38cm). At 77 DAS varietal effect on spike length varied significantly. V_2 (11.69cm) showed the highest spike length and lowest was V_1 (10.54cm). At 82 DAS varietal effect on spike length varied significantly. Maximum spike length was recorded in V_2 (11.92cm) and the lowest spike length was recorded from V_1 (10.70cm). (Table 25.)

Table 25. Effect of variety on spike length at 67DAS, 72DAS, 77DAS and 82 DAS

Variety	Spike length (cm)			
	At 67 DAS	At 72 DAS	At 77 DAS	At 82 DAS
V_1	7.75 b	10.38 b	10.54 b	10.70 b
V_2	9.18 a	11.52 a	11.69 a	11.92 a
CV	8.48	6.33	6.24	6.12
LSD	0.754	0.729	0.729	0.727

Values having same letter within a column do not differ significantly at 5% level of probability
CV=Co-efficient of variance, LSD= Least Significant Difference
V_1 = BWMRI Gom -1, V_2 = BWMRI Gom -2

4.6. Yield

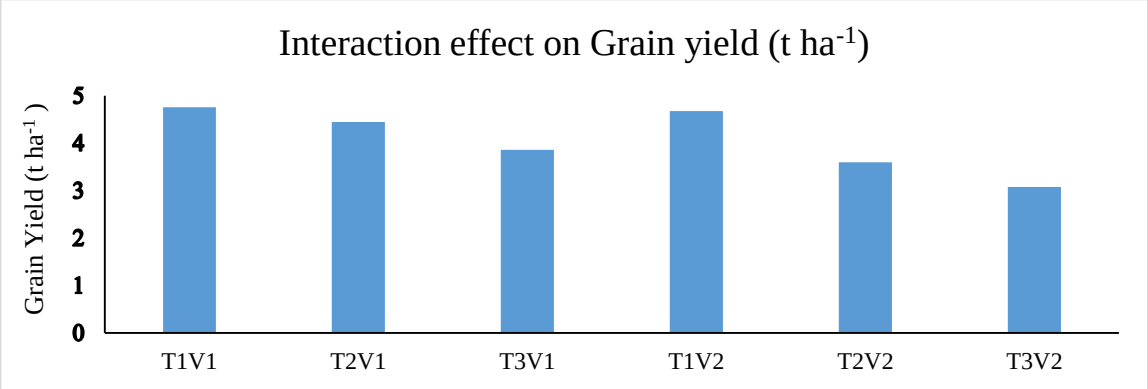
4.6.1. Interaction effect of treatment and variety on thousand grain weight (g), grain yield (t ha^{-1}), biological yield (t ha^{-1}) and harvest index (%)

4.6.1.1. Thousand grain weight (g)

Interaction effect of treatments and varieties on thousand grain weight (g) among the varieties was not varied significantly. The maximum thousand grain weight (g) was recorded from T_3V_1 (56.67gm) & T_1V_2(56.67gm) followed by T_1V_1(53.33 gm), and the lowest thousand grain weight (g) was recorded from T_2V_1(50 gm), T_2V_2(50gm) and T_3V_2(50gm). (Table 26.)

4.6.1.2. Grain yield (t ha^{-1})

Interaction effect of treatments and varieties on grain yield among the varieties was varied significantly. The maximum grain yield was recorded from T_1V_1 (4.76 t ha^{-1}) followed by T_1V_2(4.68 t ha^{-1}), T_2V_1(4.45 t ha^{-1}) T_3V_1(3.86 t ha^{-1}), T_2V_2(3.60 t ha^{-1}) and the lowest grain yield was recorded from T_3V_2(3.08t ha^{-1}). (Table 26.)



T1 = Silicon dioxide @ 60 kg ha^{-1}, T2 = Silicon dioxide @ 120 kg ha^{-1}, T3= Silicon dioxide @ 180 kg ha^{-1}, V_1 = BWMRI Gom -1, V_2 = BWMRI Gom -2

Figure **8.** Interaction effect of Treatment and variety on Grain yield (t ha^{-1})

4.6.1.3. Biological yield (t ha^{-1})

Interaction effect of treatments and varieties on biological yield among the varieties was varied significantly. The maximum biological yield was recorded from T_1V_2 (8.55 t ha^{-1}) followed by T_1V_1(8.29 t ha^{-1}), T_3V_1(8.05 t ha^{-1}), T_2V_1(7.12 t ha^{-1}), T_2V_2(6.97 t ha^{-1}) and the lowest biological yield was recorded from T_3V_2(6.38 t ha^{-1}). (Table 26.)

4.6.1.4. Harvest Index (%)

Interaction effect of treatments and varieties on harvest index (%) among the varieties was not varied significantly. The maximum harvest index (%) was recorded from T_2V_1 (63.43%) followed by T_1V_1(57.48%), T_1V_2(54.76%), T_2V_2(52.12%), T_3V_1(49.08%) and the lowest harvest index (%) was recorded from T_3V_2(48.86%). (Table 26.)

Table 26. Interaction effect of treatment and variety on thousand grain weight (g), grain yield (t ha-1), biological yield (t ha-1) and harvest index (%)

Interaction of Treatment ×Variety	Thousand grain Yield (g)	Grain yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest Index (%)
T_1V_1	53.33 a	4.76 a	8.29 ab	57.48 a
T_2V_1	50.00 a	4.45 ab	7.12 abc	63.43 a
T_3V_1	56.67 a	3.86 bc	8.05 ab	49.08 a
T_1V_2	56.67 a	4.68 a	8.55 a	54.76 a
T_2V_2	50.00 a	3.60 cd	6.97 bc	52.12 a
T_3V_2	50.00 a	3.08 d	6.38 c	48.86 a
CV	13.69	10.45	10.95	16.54
LSD	13.147	0.774	1.506	16.331

CV=Co-efficient of variance
LSD= Least Significant Difference
T1 = Silicon dioxide @ 60 kg ha^{-1}
T2 = Silicon dioxide @ 120 kg ha^{-1}
T3= Silicon dioxide @ 180 kg ha^{-1}
V_1 = BWMRI Gom -1
V_2 = BWMRI Gom -2

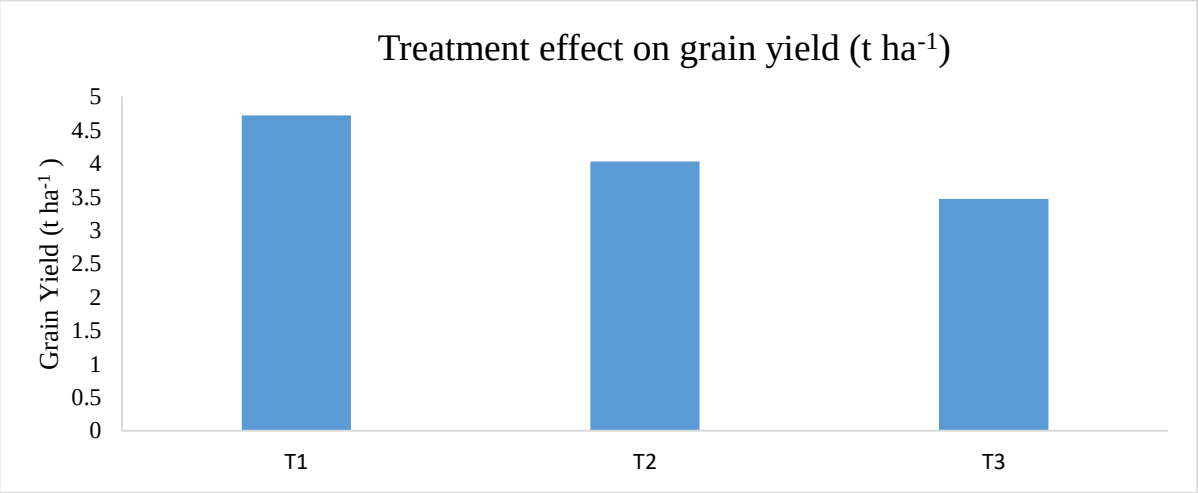
4.6.2. Effect of treatment on thousand grain weight (g), grain yield (t ha^{-1}), biological yield (t ha^{-1}) and harvest index (%)

4.6.2.1. Thousand grain weight (g)

Effect of treatment on thousand grain weight (g) among the varieties was not varied significantly. The maximum thousand grain weight (g) was recorded from T_1 (55.0gm) followed by T_3 (53.33gm) and the lowest thousand grain weight (g) was recorded from T_2(50 gm). (Table 27.)

4.6.2.2. Grain yield (t ha^{-1})

Effect of treatment on grain yield among the varieties was varied significantly. The maximum grain yield was recorded from T_1 (4.72 t ha^{-1}) followed by T_2 (4.03 t ha^{-1}) and the lowest Grain yield was recorded from T_1 (3.47 t ha^{-1}). (Table 27.)



T_1 = Silicon dioxide @ 60 kg ha^{-1}
T_2 = Silicon dioxide @ 120 kg ha^{-1}
T_3= Silicon dioxide @ 180 kg ha^{-1}

Figure 9. Treatment effect on grain yield (t ha^{-1})

4.6.2.3. Biological yield (t ha^{-1})

Effect of Treatment on biological yield among the varieties was varied significantly. The maximum biological yield was recorded from T_1 (8.42 t ha^{-1}) followed by T_3 (7.22 t ha^{-1}) and the lowest biological yield was recorded from T_2 (7.05 t ha^{-1}). (Table 27.)

4.6.2.4. Harvest Index (%)

Effect of treatment on Harvest Index (%) among the varieties was not varied significantly. The maximum Harvest Index (%) was recorded from T_2 (57.77%) followed by T_1 (56.12%) and the lowest Harvest Index (%) was recorded from T_3 (48.97%). (Table 27.)

Table 27. Effect of treatment on thousand grain weight (g), grain yield (t ha^{-1}), biological yield (t ha^{-1}) and harvest index (%)

Treatment	Thousand grain Yield (g)	Grain yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest Index (%)
T_1	55.00 a	4.72 a	8.42 a	56.12 a
T_2	50.00 a	4.03 b	7.05 b	57.77 a
T_3	53.33 a	3.47 c	7.22 b	48.97 a
CV	13.69	10.45	10.95	16.54
LSD	9.296	0.548	1.065	11.548

Values having same letter within a column do not differ significantly at 5% level of probability
CV=Co-efficient of variance, LSD= Least Significant Difference, T_1 = Silicon dioxide @ 60 kg ha^{-1}, T_2 = Silicon dioxide @ 120 kg ha^{-1}, T_3= Silicon dioxide @ 180 kg ha^{-1}

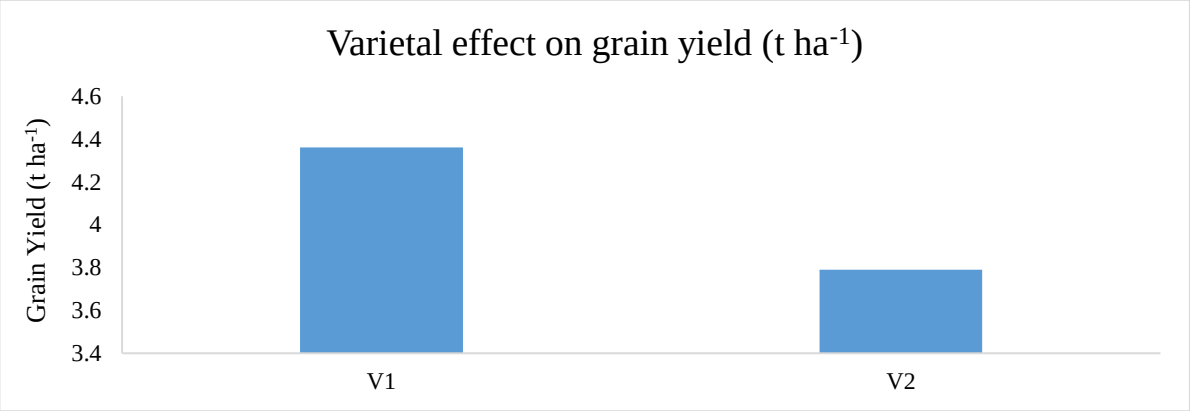
4.6.3. Varietal effect on thousand grain weight (g), grain yield (t ha^{-1}), biological yield (t ha^{-1}) and harvest index (%)

4.6.3.1. Thousand grain weight (g)

Varietal effect on thousand grain weight (g) among the varieties was not varied significantly. The maximum thousand grain weight (g) was recorded from V_1 (53.33gm) and the lowest thousand grain weight (g) was recorded from V_2 (52.22 gm). (Table 28.)

4.6.3.2. Grain yield (t ha^{-1})

Varietal effect on grain yield among the varieties was varied significantly. The maximum grain yield was recorded from V_1 (4.36 t ha^{-1}) and the lowest grain yield was recorded from V_2 (3.79 t ha^{-1}). (Table 28.)



V_1 = BWMRI Gom -1
V_2 = BWMRI Gom -2

Figure 10. Varietal effect on grain yield (t ha^{-1})

4.6.3.3. Biological yield (t ha^{-1})

Varietal effect on biological yield among the varieties was not varied significantly. The maximum biological yield was recorded from V_1 (7.82 t ha^{-1}) and the lowest biological yield was recorded from V_2 (7.30 t ha^{-1}). (Table 28.)

4.6.3.4. Harvest Index (%)

Varietal effect on harvest index (%) among the varieties was not varied significantly. The maximum harvest index (%) was recorded from V_1 (56.66%) and the lowest harvest index (%) was recorded from V_2 (51.91%). (Table 28.)

Table 28. Varietal effect on thousand grain weight (g), grain yield (t ha^{-1}), biological yield (t ha^{-1}) and harvest index (%)

Variety	Thousand grain Yield (g)	Grain Yield (t ha^{-1})	Biological Yield (t ha^{-1})	Harvest Index (%)
V_1	53.33 a	4.36 a	7.82 a	56.66 a
V_2	52.22 a	3.79 b	7.30 a	51.91 a
CV	13.69	10.45	10.95	16.54
LSD	7.5904	0.447	0.869	9.429

Values having same letter within a column do not differ significantly at 5% level of probability
CV=Co-efficient of variance
LSD= Least Significant Difference
V_1 = BWMRI Gom -1
V_2 = BWMRI Gom -2

4.7. Regression between *Bipolaris* leaf blight severity with grain yield of Wheat

4.7.1. Interaction effect of treatment and variety on regression between *Bipolaris* leaf blight severity (Flag leaf) with yield of potato

At 67 DAS the liner regression analysis found negative relationship between *Bipolaris* leaf blight disease severity with grain yield. However, grain yield response to the intensity of the *Bipolaris* leaf blight disease severity which can be determined by the regression equation y = -0.3965x + 5.0597 (R^2 = 0.18689). The fitted line plot showed the regression results graphically with equation between dependent variable of grain yield and independent variable of *Bipolaris* leaf blight disease severity. The equation indicates the grain yield decrease at the rate of 0.3965 with an increase of one unit of percent *Bipolaris* leaf blight disease severity. The R^2 value of 0.18689 indicates yield can be explained as 18.689% by the respective function. Figure 11(a)

At 72 DAS grain yield response to the intensity of the *Bipolaris* leaf blight disease severity which can be determined by the regression equation y = -0.1656x + 5.1946 (R^2 = 0.4052738).

The equation indicates the grain yield decrease at the rate of 0.1656 with an increase of one unit of percent *Bipolaris* leaf blight disease severity. The R^2 value of 0.4052738 indicates yield can be explained as 40.527% by the respective function. Figure 11(b)

At 77 DAS grain yield response to the intensity of the *Bipolaris* leaf blight disease severity which can be determined by the regression equation y= -0.1772x + 5.5021 (R^2 = 0.5779). The equation indicates the grain yield decrease at the rate of 0.1772 with an increase of one unit of percent *Bipolaris* leaf blight disease severity. The R^2 value of 0.5779 indicates yield can be explained as 58% by the respective function. Figure 11(c)

At 82 DAS grain yield response to the intensity of the *Bipolaris* leaf blight disease severity which can be determined by the regression equation y = -0.1659x + 5.9222 (R^2 = 0.820750781). The equation indicates the grain yield decrease at the rate of 0.1659 with an increase of one unit of percent *Bipolaris* leaf blight disease severity. The R^2 value of 0.82 indicates yield can be explained as 82% by the respective function. Figure 11(d)

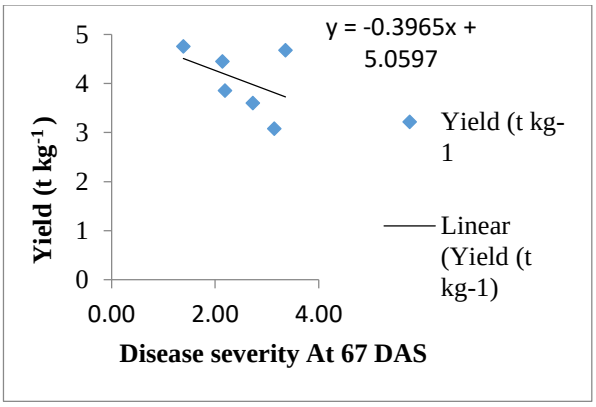


Figure 11(a)

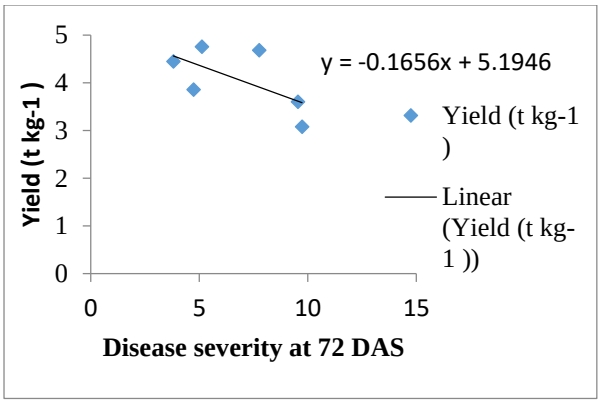


Figure 11(b)

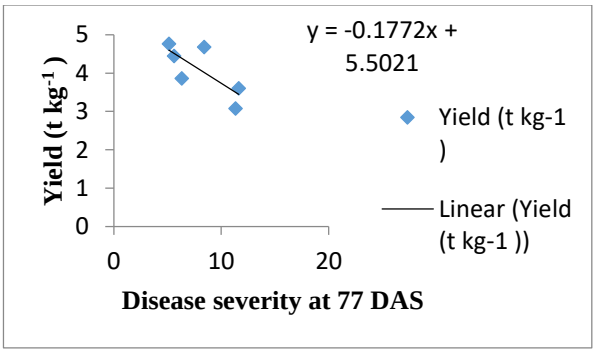


Figure 11 (c)

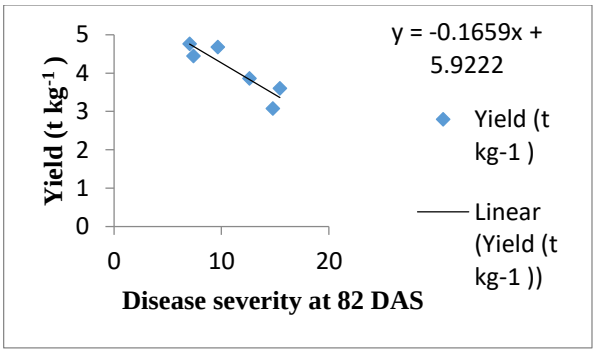


Figure 11(d)

Figure 11. Interaction effect of Treatment and variety on Regression between *Bipolaris* leaf blight severity (Flag leaf) with yield of potato at 67 DAS, 72 DAS, 77 DAS, 82 DAS

4.7.2. Interaction effect of Treatment and variety on Regression between *Bipolaris* leaf blight severity (Flag-1 leaf) with Grain yield of wheat

At 67 DAS the liner regression analysis found negative relationship between *Bipolaris* leaf blight disease severity with grain yield. However, grain yield response to the intensity of the *Bipolaris* leaf blight disease severity which can be determined by the regression equation y = -0.2643x + 4.6235 (R^2 = 0.412938858). The fitted line plot showed the regression results graphically with equation between dependent variable of grain yield and independent variable of *Bipolaris* leaf blight disease severity. The equation indicates the grain yield decrease at the rate of 0.2643 with an increase of one unit of percent *Bipolaris* leaf blight disease severity. The R^2 value of 0.412938858 indicates yield can be explained as 41.293% by the respective function. Figure 12(a)

At 72 DAS grain yield response to the intensity of the *Bipolaris* leaf blight disease severity which can be determined by the regression equation y = -0.1608x + 4.7929 (R^2 = 0.434194013). The equation indicates the grain yield decrease at the rate of 0.1608 with an increase of one unit of percent *Bipolaris* leaf blight disease severity. The R^2 value of 0.434194013 indicates yield can be explained as 43.419% by the respective function. Figure 12(b)

At 77 DAS grain yield response to the intensity of the *Bipolaris* leaf blight disease severity which can be determined by the regression equation y = -0.0985x + 5.0549 (R^2 = 0.753382777). The equation indicates the grain yield decrease at the rate of 0.0985 with an increase of one unit of percent *Bipolaris* leaf blight disease severity. The R^2 value of 0.753382777indicates yield can be explained as 75.753% by the respective function. Figure 12(c)

At 82 DAS grain yield response to the intensity of the *Bipolaris* leaf blight disease severity which can be determined by the regression equation y = -0.0587x + 5.1048 (R^2 = 0.757110188). The equation indicates the grain yield decrease at the rate of .0587 with an increase of one unit of percent *Bipolaris* leaf blight disease severity. The R^2 value of 0.757110188 indicates yield can be explained as 75.711% by the respective function. Figure 12(d)

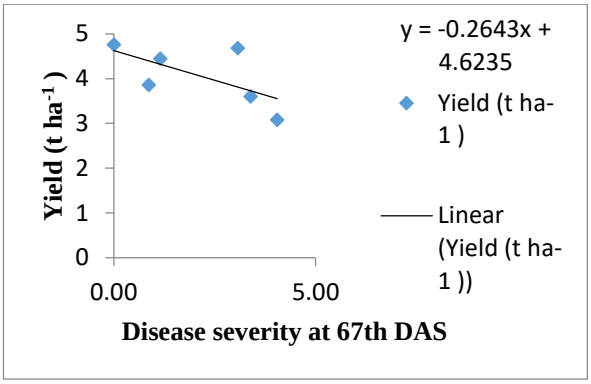


Figure 12(a)

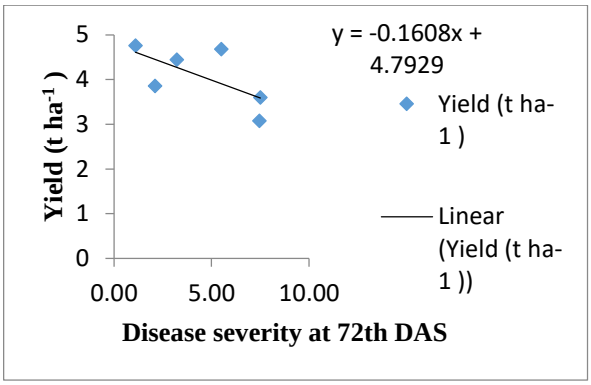


Figure 12 (b)

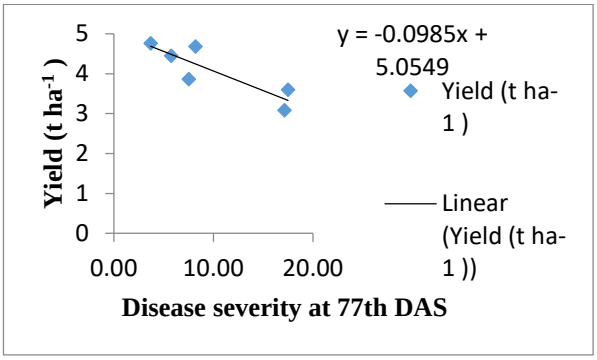


Figure 12(c)

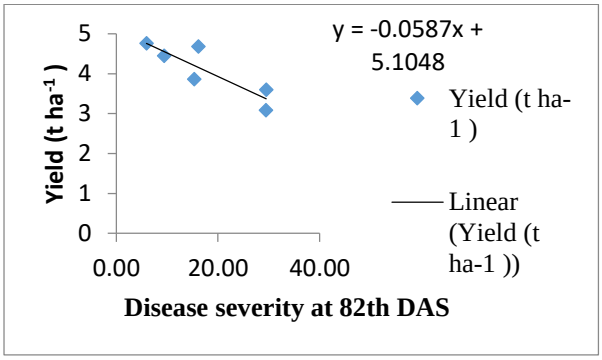


Figure 12(d)

Figure 12. Interaction effect of Treatment and variety on Regression between *Bipolaris* leaf blight severity (Flag-1 leaf) with Grain yield of wheat at 67 DAS, 72 DAS, 77 DAS, 82 DAS

4.7.3. Treatment on Regression between *Bipolaris* leaf blight severity (Flag leaf) with Grain yield of wheat

At 67 DAS the linear regression analysis found negative relationship between *Bipolaris* leaf blight disease severity with grain yield. However, grain yield response to the intensity of the *Bipolaris* leaf blight disease severity which can be determined by the regression equation y = -3.8865x + 13.751 (R^2 = 0.882310679). The fitted line plot showed the regression results graphically with equation between dependent variable of grain yield and independent variable of *Bipolaris* leaf blight disease severity. The equation indicates the grain yield decrease at the rate of 3.8865 with an increase of one unit of percent *Bipolaris* leaf blight disease severity. The R^2 value of 0.882310679 indicates yield can be explained as 88.231% by the respective function. Figure 13(a)

At 72 DAS grain yield response to the intensity of the *Bipolaris* leaf blight disease severity which can be determined by the regression equation y = -1.4737x + 14.065 (R^2 = 0.914564099).

The equation indicates the grain yield decrease at the rate of 1.4737 with an increase of one unit of percent *Bipolaris* leaf blight disease severity. The R^2 value of 0.914564099indicates yield can be explained as 91.456% by the respective function. Figure 13(b)

At 77 DAS grain yield response to the intensity of the *Bipolaris* leaf blight disease severity which can be determined by the regression equation y = -0.5148x + 8.2294 (R^2 = 0.868648737). The equation indicates the grain yield decrease at the rate of 0.5148 with an increase of one unit of percent *Bipolaris* leaf blight disease severity. The R^2 value of 0.868648737 indicates yield can be explained as 86.86% by the respective function. Figure 13(c)

At 82 DAS grain yield response to the intensity of the *Bipolaris* leaf blight disease severity which can be determined by the regression equation y = -0.2336x + 6.6782 (R^2 = 0.999308087). The equation indicates the grain yield decrease at the rate of 0.2336 with an increase of one unit of percent *Bipolaris* leaf blight disease severity. The R^2 value of 0.999308087 indicates yield can be explained as 99.93% by the respective function. Figure 13(d)

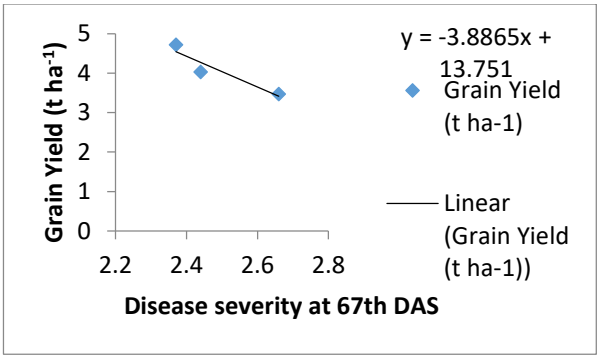


Figure 13(a)

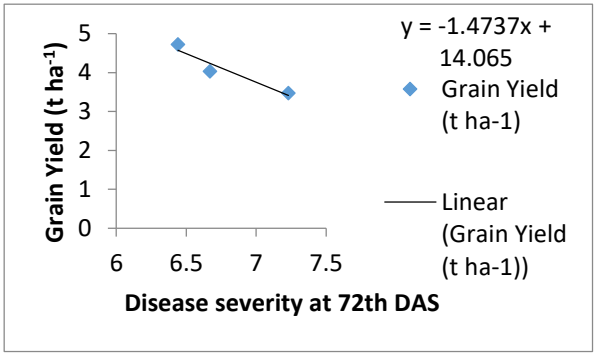


Figure 13(b)

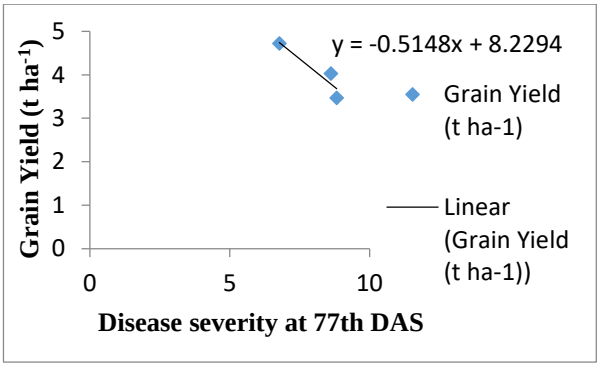


Figure 13(c)

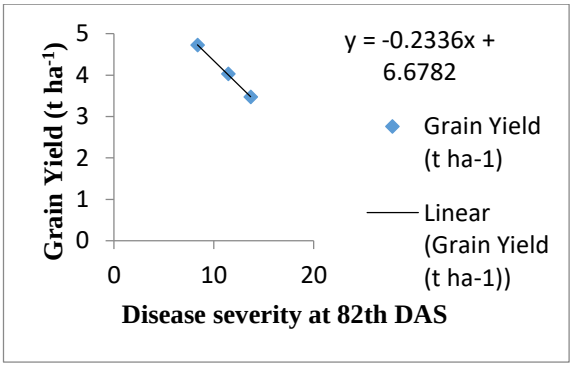


Figure 13(d)

Figure 13. Treatment on Regression between *Bipolaris* leaf blight severity (Flag leaf) with Grain yield of wheat at 67 DAS, 72 DAS, 77 DAS, 82 DAS

4.7.4. Treatment on Regression between *Bipolaris* leaf blight severity (Flag-1 leaf) with Grain yield of wheat

At 67 DAS the linear regression analysis found negative relationship between *Bipolaris* leaf blight disease severity with grain yield. However, grain yield response to the intensity of the *Bipolaris* leaf blight disease severity which can be determined by the regression equation y = -1.2435x + 6.6723 (R^2 = 0.930510438). The fitted line plot showed the regression results graphically with equation between dependent variable of grain yield and independent variable of *Bipolaris* leaf blight disease severity. The equation indicates the grain yield decrease at the rate of 1.2435 with an increase of one unit of percent *Bipolaris* leaf blight disease severity. The R^2 value of 0.930510438 indicates yield can be explained as 93.051% by the respective function. Figure 14(a)

At 72 DAS grain yield response to the intensity of the *Bipolaris* leaf blight disease severity which can be determined by the regression equation y = -0.4337x + 6.0191 (R^2 = 0.539939608). The equation indicates the grain yield decrease at the rate of 0.4337 with an increase of one unit of percent *Bipolaris* leaf blight disease severity. The R^2 value of 0.5399 indicates yield can be explained as 53.99% by the respective function. Figure 14(b)

At 77 DAS grain yield response to the intensity of the *Bipolaris* leaf blight disease severity which can be determined by the regression equation y = -0.1653x + 5.7387 (R^2 = 0.898674517). The equation indicates the grain yield decrease at the rate of 0.1653 with an increase of one unit of percent *Bipolaris* leaf blight disease severity. The R^2 value of 0.89867 indicates yield can be explained as 89.867% by the respective function. Figure 14(c)

At 82 DAS grain yield response to the intensity of the *Bipolaris* leaf blight disease severity which can be determined by the regression equation y = -0.1051x + 5.927 (R^2 = 0.95679). The equation indicates the grain yield decrease at the rate of 0.1051 with an increase of one unit of percent *Bipolaris* leaf blight disease severity. The R^2 value of 0.95679 indicates yield can be explained as 95.68% by the respective function. Figure 14(d)

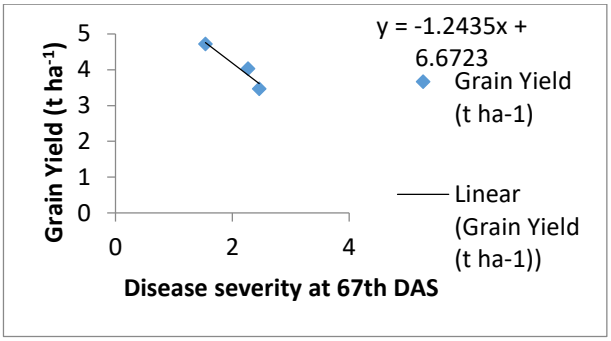


Figure 14(a)

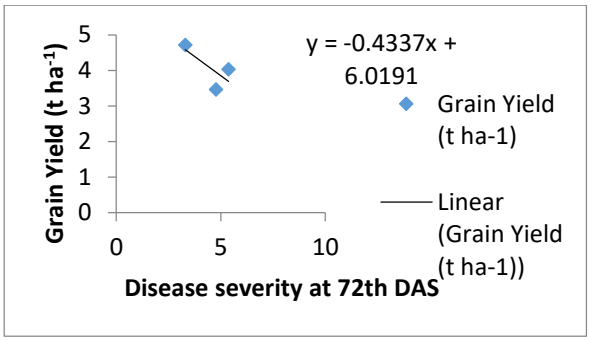


Figure 14(b)

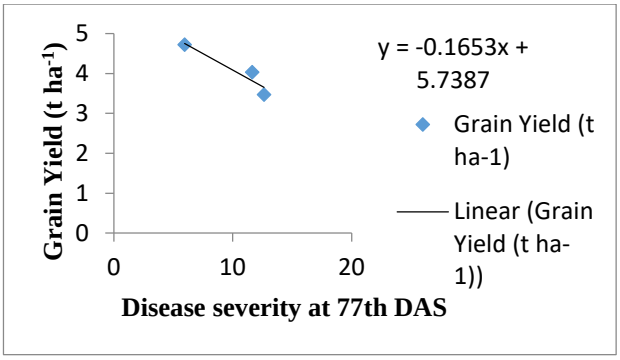


Figure 14(c)

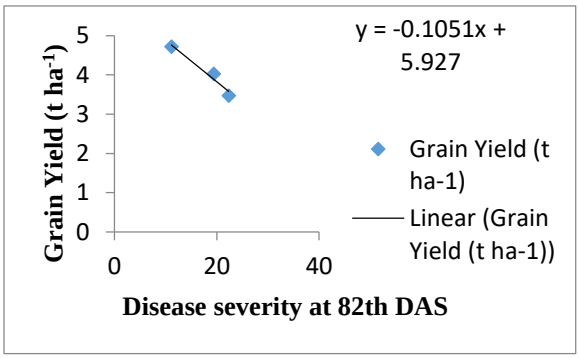


Figure 14(d)

Figure 14. Treatment on Regression between *Bipolaris* leaf blight severity (Flag-1 leaf) with Grain yield of wheat at 67 DAS, 72 DAS, 77 DAS, 82 DAS

4.7.5. Varietal effect on Regression between *Bipolaris* leaf blight severity (Flag leaf) with Grain yield of wheat

At 67 DAS the linear regression analysis found negative relationship between *Bipolaris* leaf blight disease severity with grain yield. However, grain yield response to the intensity of the *Bipolaris* leaf blight disease severity which can be determined by the regression equation y = -0.4831x + 5.2778 (R^2 = 1). The fitted line plot showed the regression results graphically with equation between dependent variable of grain yield and independent variable of *Bipolaris* leaf blight disease severity. The equation indicates the grain yield decrease at the rate of 0.4831 with an increase of one unit of percent *Bipolaris* leaf blight disease severity. The R^2 value of 1 indicates yield can be explained as 100% by the respective function. Figure 15(a)

At 72 DAS grain yield response to the intensity of the *Bipolaris* leaf blight disease severity which can be determined by the regression equation y = -0.1278x + 4.9415 (R^2 = 1). The equation indicates the grain yield decrease at the rate of 0.1278 with an increase of one unit of percent *Bipolaris* leaf blight disease severity. The R^2 value of 1 indicates yield can be explained as 100% by the respective function. Figure 15(b)

At 77 DAS grain yield response to the intensity of the *Bipolaris* leaf blight disease severity which can be determined by the regression equation y = -0.1197x + 5.0411 (R^2 = 1). The equation indicates the grain yield decrease at the rate of 0.1197 with an increase of one unit of percent *Bipolaris* leaf blight disease severity. The R^2 value of 1 indicates yield can be explained as 100% by the respective function. Figure 15(c)

At 82 DAS grain yield response to the intensity of the *Bipolaris* leaf blight disease severity which can be determined by the regression equation y = -0.1332x + 5.5599 (R^2 = 1). The equation indicates the grain yield decreases at the rate of 0.1332 with an increase of one unit of percent *Bipolaris* leaf blight disease severity. The R^2 value of 1 indicates yield can be explained as 100% by the respective function. Figure 15(d)

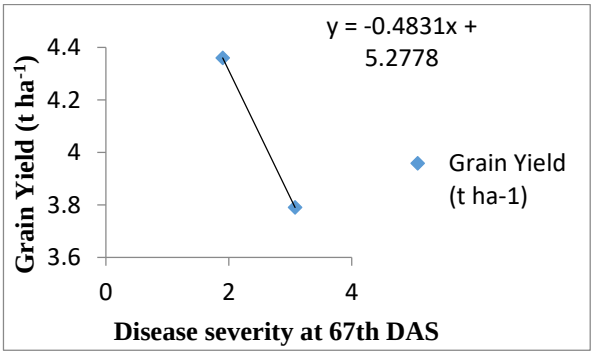


Figure 15(a)

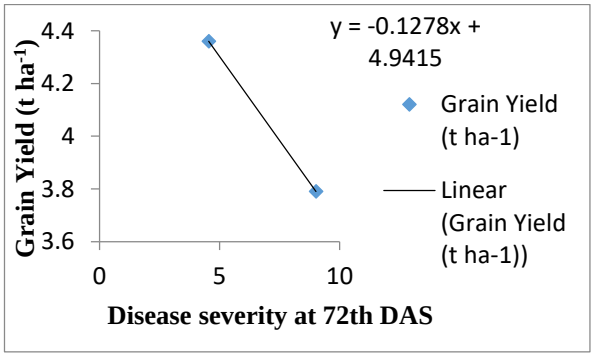


Figure 15(b)

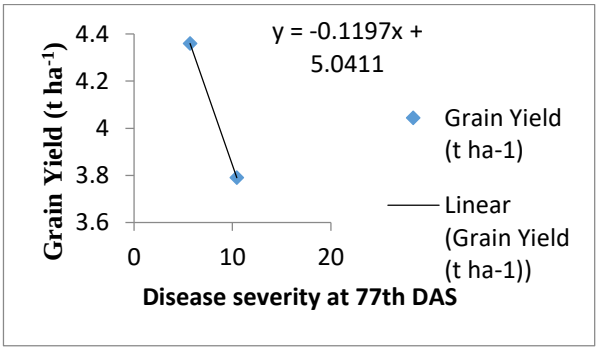


Figure 15(c)

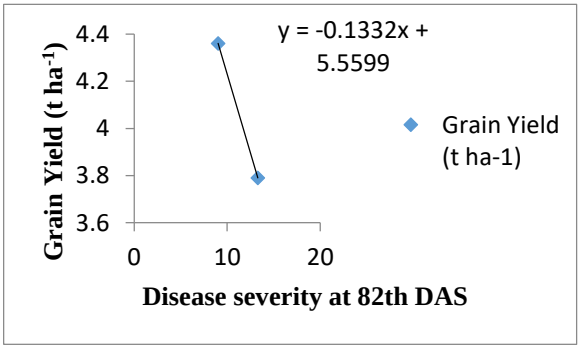


Figure 15(d)

Figure 15. Varietal effect on Regression between *Bipolaris* leaf blight severity (Flag leaf) with Grain yield of wheat at 67 DAS, 72 DAS, 77 DAS, 82 DAS

4.7.6. Varietal effect on Regression between *Bipolaris* leaf blight severity (Flag-1 leaf) with Grain yield of wheat

At 67 DAS the linear regression analysis found negative relationship between *Bipolaris* leaf blight disease severity with grain yield. However, grain yield response to the intensity of the *Bipolaris* leaf blight disease severity which can be determined by the regression equation $y = -0.2007x + 4.4945$ ($R^2 = 1$). The fitted line plot showed the regression results graphically with equation between dependent variable of grain yield and independent variable of *Bipolaris* leaf blight disease severity. The equation indicates the grain yield decrease at the rate of 0.2007 with an increase of one unit of percent *Bipolaris* leaf blight disease severity. The R^2 value of 1 indicates yield can be explained as 100% by the respective function. Figure 16(a)

At 72 DAS grain yield response to the intensity of the *Bipolaris* leaf blight disease severity which can be determined by the regression equation $y = -0.1221x + 4.6224$ ($R^2 = 1$). The equation indicates the grain yield decrease at the rate of 0.1221 with an increase of one unit of percent *Bipolaris* leaf blight disease severity. The R^2 value of 1 indicates yield can be explained as 100% by the respective function. Figure 16(b)

At 77 DAS grain yield response to the intensity of the *Bipolaris* leaf blight disease severity which can be determined by the regression equation $y = -0.0662x + 4.7362$ ($R^2 = 1$). The equation indicates the grain yield decrease at the rate of 0.0662 with an increase of one unit of percent *Bipolaris* leaf blight disease severity. The R^2 value of 1 indicates yield can be explained as 100% by the respective function. Figure 16(c)

At 82 DAS grain yield response to the intensity of the *Bipolaris* leaf blight disease severity which can be determined by the regression equation $y = -0.0383x + 4.7506$ ($R^2 = 1$). The equation indicates the grain yield decrease at the rate of 0.0383 with an increase of one unit of percent *Bipolaris* leaf blight disease severity. The R^2 value of 1 indicates yield can be explained as 100% by the respective function. Figure 16(d)

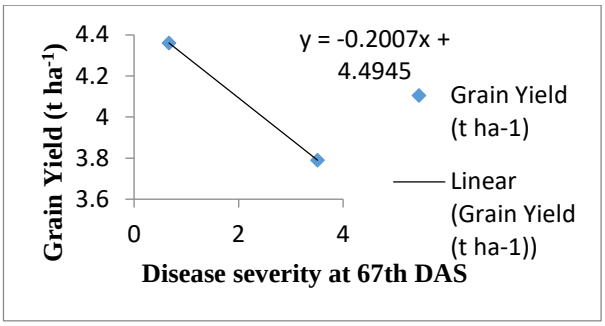


Figure 16(a)

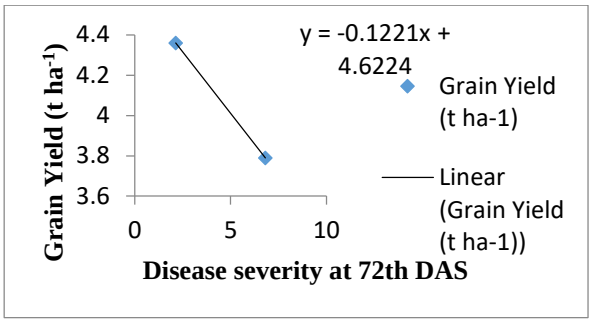


Figure 16(b)

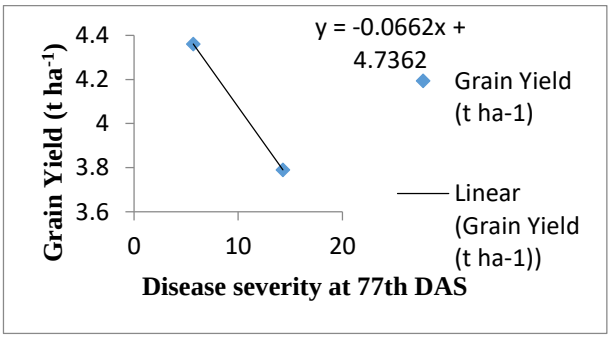


Figure 16(c)

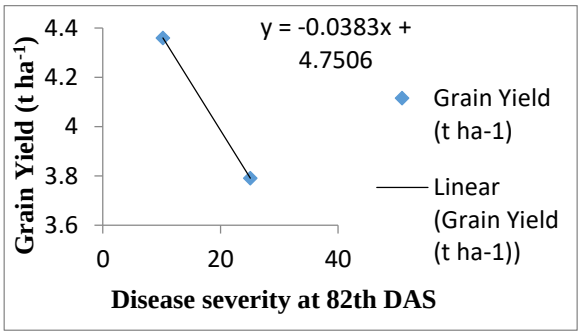


Figure 16(d)

Figure 16. Varietal effect on Regression between *Bipolaris* leaf blight severity (Flag-1 leaf) with Grain yield of wheat at 67 DAS, 72 DAS, 77 DAS, 82 DAS

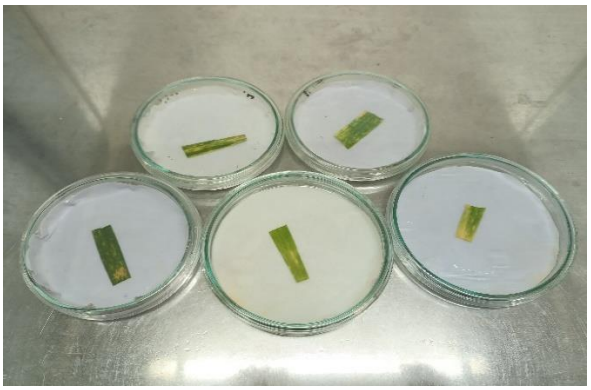


Figure 17(a). Diseased leaf sample in petri plate

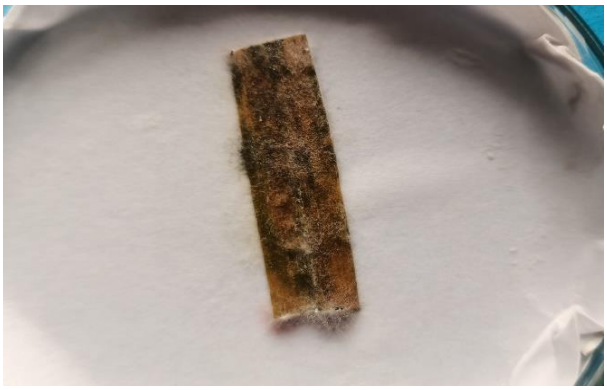


Figure 17(b). 7th day of disease development

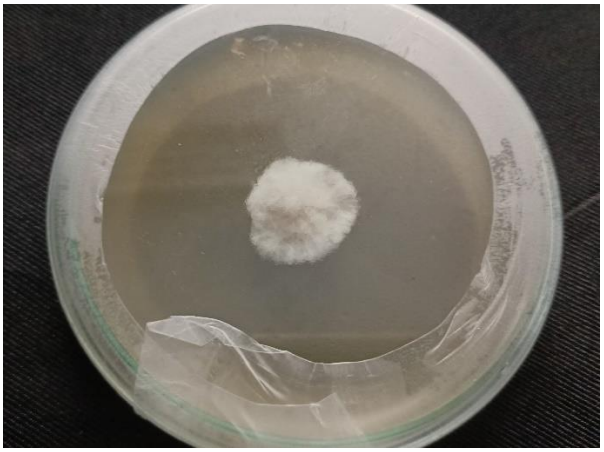


Figure 17(c). Culture on PDA media (3rd day)

Figure 17(d). Culture on PDA (7th day)

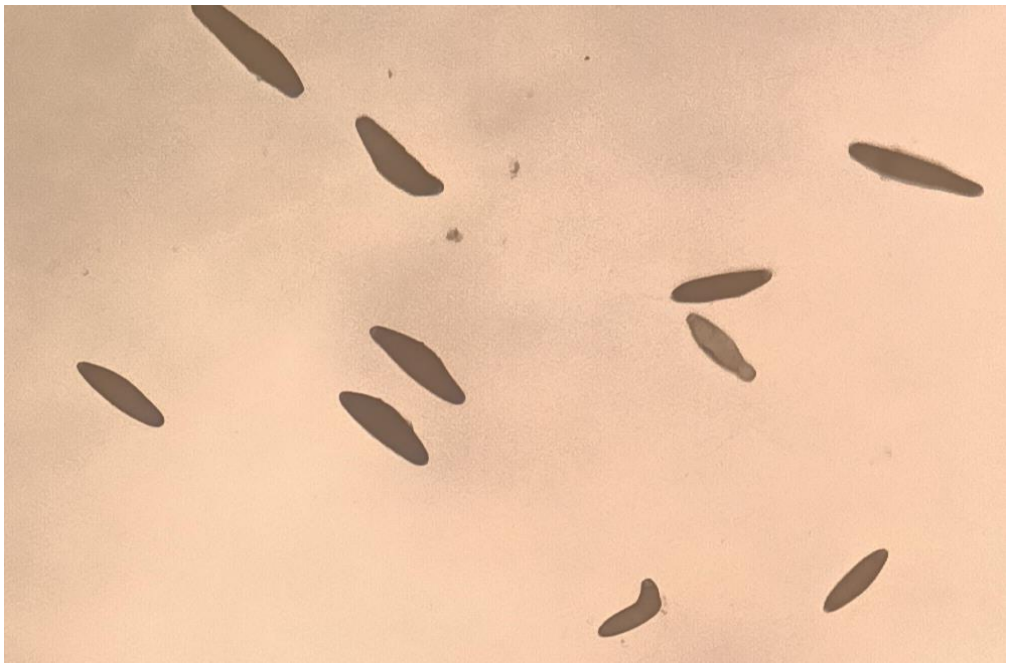


Figure 17(e). *Bipolaris sorokiniana* under binocular microscope

CHAPTER V

DISCUSSION

The experiment was conducted to find out the optimum dose of silicon dioxide against leaf blight (*Bipolaris sorokiniana*) and silicon dioxide effect on seed health and yield of wheat. Also research was conducted to find out the best performing variety of wheat against *Bipolaris* leaf blight by applying silicon dioxide. The experiment was conducted in the research field of HSTU, Dinajpur during December 2022 to April 2023. The planting material of the experiment were wheat (V_1 = BWMRI Gom -1 and V_2 = BWMRI Gom -2) and three treatments (T1 = Silicon dioxide @ 60 kg ha^1, T2 = Silicon dioxide @ 120 kg ha^{-1} and T3= Silicon dioxide @ 180 kg ha^{-1}) {(Silicon was applied as Silicon dioxide (SiO_2)}.

Bipolaris leaf blight symptoms appeared as brown lesions with yellow halos, which enlarge with time to cover larger areas of the leaf. It was also described by Al-Sadi (2016); Gupta *et al*. (2018a); Gupta *et al*. (2018b). The pathogen found under microscope had brown conidiophores, mostly simple, producing conidia through the apical pore. The conidia are brown, elliptical, straight, or curved, germinating by one germ tube at each end. The pathogen morphology of *Bipolaris sorokiniana* also similarly described by Barnett and Hunter (1998) Navathe *et al*. (2020) (Figure 17). *B. sorokiniana* has olive-brown, ovate conidia, with tapered ends and a prominent basal scar. The conidia have 3- to 10- septa (Wiese, 1987).

Disease severity, disease incidence, plant height, spike length data were taken in the research field. Seed health test was conducted in laboratory to find out the percent seed associated with pathogen and percent seed germination. Thousand seed weight, grain yield, biological yield, harvest index data were analyzed. Effect of different doses of silicon dioxide on disease and yield was tested. Data on *Bipolaris* leaf blight severity was recorded as percent diseased leaf area (%DLA) (Heztler 1992). The variety and treatment were graded for disease reaction based on Resistant(R) = 0-10%, Moderately Resistant (MR)= 11-30%, Moderately Susceptible (MS)= 31-50%, susceptible (S)=51-70% and Highly susceptible (HS) ≥ 70% DLA (Ragiba *et al*. 2001).

Fauteux *et al*. (2005) reported the success of Silicon dioxide application in reducing the incidence or severity of several diseases in diverse crops, including wheat. The expansion of the wheat crop in Brazil occurs mainly in the Cerrado region, where soil Si availability is low. Due to the attributes of Cerrado soils, it is to be expected that the plant response to Si application will be positive, mainly for Si-accumulating plants, as in the case of crops of the *Gramineae* family, including wheat.

The results revealed that at 67 DAS, 72 DAS, 77 DAS and 82 DAS as a treatment, maximum disease severity on flag leaf was recorded from T_3 (2.66%), T_3 (7.23%), T_3 (8.83%) and T_3 (13.69%) respectively. As a treatment, the lowest disease severity on flag leaf was recorded from T_1 (2.37%), T_1(6.44%), T_1 (6.77%) and T_1 (8.35%) respectively. According to Ragiba *et al*. (2001) the application of T_1 showed *Bipolaris* leaf blight disease resistance at all of the plant growth stage. The result of three doses were similar at 67 and 72 DAS as they were not significant. But at 77DAS and 82 DAS T_1 varied significantly with T_2 & T_3. At 67 DAS, 72 DAS, 77 DAS and 82 DAS as a variety, maximum disease severity on flag leaf was recorded from V_2 (3.08%), V_2 (9.01%), V_2 (10.45%) and V_2 (13.29%) respectively and the lowest disease severity on flag leaf in V_1 (1.90%), V_1 (4.55%), V_1 (5.69%) and V_1 (9.01%) respectively. According to Ragiba *et al*. (2001) the application of V_1 showed *Bipolaris* leaf blight disease resistance at 67 DAS, 72 DAS, 77 DAS and 82 DAS. While V_2 showed moderate resistance at 77DAS and 82 DAS. Here, V_1 & V_2 varied significantly. The results revealed that at 67 DAS, 72 DAS, 77 DAS and 82 DAS treatment variety interaction showed maximum disease severity on flag leaf from T_1V_2 (3.36%), T_3V_2 (9.73%), T_2V_2 (11.62%) and T_2V_2 (15.43%) respectively and the lowest disease severity on flag leaf from T_1V_1 (1.39%), T_2V_1 (3.80%), T_1V_1 (5.12%) and T_1V_1 (7.03%) respectively. According to Ragiba *et al*. (2001) the interaction of T_1V_1 showed the highest *Bipolaris* leaf blight disease resistance than other treatment and variety combination. T_2V_2 showed moderate resistance against leaf blight at 77 and 82 DAS.

The results revealed that at 67 DAS, 72 DAS, 77 DAS and 82 DAS as a treatment, maximum disease severity on flag-1 leaf was recorded from T_3 (2.46%), T_2 (5.37%), T_3 (12.63%) and T_3 (22.35%) respectively and the lowest disease severity on flag-1 leaf was recorded from T_1 (1.54%), T_1(3.31%), T_1 (5.97%) and T_1 (11.12%) respectively. According to Ragiba *et al*. (2001) the application of T_1 showed the highest *Bipolaris* leaf blight disease resistance at 67 DAS, 72 DAS, 77 DAS. Here T_1 was significantly effective against *Bipolaris* leaf blight than other treatments. It was found that at 67 DAS, 72 DAS, 77 DAS and 82 DAS as a variety, maximum disease severity on flag-1 leaf was recorded from V_2 (3.51%), V_2 (6.82%), V_2 (14.29%) and V_2 (25.06%) respectively and the lowest disease severity on flag-1 leaves in V_1 (0.67%), V_1 (2.15%), V_1 (5.68%) and V_1 (10.19%) respectively. According to Ragiba *et al*. (2001) V_1 showed *Bipolaris* leaf blight disease resistance significantly at 67 DAS, 72 DAS, 77 DAS and moderate resistance at 82 DAS. While V_2 showed resistance at 67DAS & 72DAS and moderate resistance at 77DAS and 82 DAS. At 67 DAS, 72 DAS, 77 DAS and 82 DAS

treatment variety interaction showed maximum disease severity on flag-1 leaf at T_3V_2 (4.05%), T_2V_2 (7.50%), T_2V_2 (17.49%) and T_2V_2 (29.46%) respectively and the lowest disease severity on flag-1 leaf at T_1V_1 (0.0%), T_1 V_1 (1.11%), T_1V_1 (3.72%) and T_1 V_1 (5.92%) respectively. According to Ragiba *et al*. (2001) the interaction of T_1V_1 showed the highest *Bipolaris* leaf blight disease resistance than other treatment and variety combination.

In this research V_1 showed blight disease severity at a range of 1.90% to 9.01% for flag leaf and 0.67% to 10.19% for flag-1 leaf. Mustarin *et al*. (2022) conducted a research in field condition in Jashore with 11 wheat varieties and blight severity of the selected varieties recorded varied from 1.25% to 12.50%. The use of silicon dioxide was also found to improve resistance of wheat leaves to *B. sorokiniana* infection. Domiciano *et al*. (2010) conducted a research, that work aimed to evaluate the effect of silicon dioxide (Si) on the progress of *Bipolaris sorokiniana* management, on the flag leaf of wheat plants. The severity of brown spot on the flag leaf was significantly lower in plants supplied with Si at all evaluation time. For leaf blight (*Bipolaris sorokiniana*) the AUDPC was reduced by 59% due soil fertilization with calcium silicate (wollastonite).

It was discovered that *Bipolaris sorokiniana* was one of the most common fungi. In Bangladesh, eight different species of *Bipolaris* were identified using the freezing blotter method. Rashid *et al*. (1992) reported that *B. sorokiniana (Cochliobolus sativus)* was the most prevalent species. Rangpur district farmers' wheat seed quality and condition were assessed by Mahmud (2005). In all, he discovered that over 80% of the samples from Rangpur sadar and 12 out of 20 samples from Mithapukur thana appeared to be healthy seed. From the seed samples, he isolated seven fungi, the most common of which was *Bipolaris sorokiniana*. We collected newly harvested seeds from treated plot to find out the percent seed affected with seed borne pathogen. Treatment variety interaction showed maximum seed number was affected with *Bipolaris sorokiniana* at T_3V_2 (17.66%) and minimum at T_1V_1 (8.18%). Interactions varied significantly. As a treatment, maximum seed number was affected with *Bipolaris sorokiniana* was recorded from T_3 (16.50%) and minimum from T_1(10.13%). As a Vriety, maximum seed number was affected with *Bipolaris sorokiniana* was recorded from V_2 (14.78%) and minimum from V_1(10.92%). The result showed that T_1, V_1 and their interaction had influence to reduce *Bipolaris sorokiniana* as a seed borne pathogen. Other four pathogens *Fusarium, Aspergillus, Curvularia* and *Colletotrichum* are found to be reduced in T_1, V_1 and in their interaction also.

The linear regression analysis found negative relationship between *Bipolaris* leaf blight disease severity with grain yield. The fitted line plot showed the regression results graphically with equation between dependent variable of grain yield and independent variable of *Bipolaris* leaf blight disease severity. The equation indicated that the grain yield decreases with an increase of one unit of percent *Bipolaris* leaf blight disease severity. Leaf blight (*Bipolaris sorokiniana*) has been reported to cause 15% grain yield reduction in Bangladesh (Alam *et al*., 1998) and China (Xiao *et al*., 1998). This disease is major constraint of wheat cultivation causing severe reduction of yield up to 40% and 88% over control, under natural field condition and artificial inoculation, respectively (Hossain *et al*., 1998).

The results of this study showed that application of Silicon dioxide in wheat cultivation had a promising effect in reducing *Bipolaris* leaf blight disease. Additionally, Silicon dioxide had a significant positive impact on grain yield, seed quality, plant height, spike length, and seedling emergence.

CHAPTER VI

SUMMARY

Wheat is an important cereal crop in Bangladesh. *Bipolaris* leaf blight caused by *Bipolaris sorokiniana* is a major biotic constrain affecting wheat production in Bangladesh. However, the quality of wheat is very low in compare to other wheat growing countries because of diseases and lack of quality healthy seeds. Therefore, an investigation was carried out to know the efficacy of silicon dioxide for reducing *Bipolaris* leaf blight disease and production of quality healthy wheat seed. The treatments used in the experiment were T_1 (Silicon dioxide @ 60 kg ha^{-1}), T_2 (Silicon dioxide @ 120 kg ha^{-1}) and T_3(Silicon dioxide @ 180 kg ha^{-1}). The varieties used were V_1 (BWMRI Gom-1) and V_2 (BWMRI Gom-2). BWMRI Gom-1 showed minimum disease severity and maximum found in BWMRI Gom-1. The highest percent diseased severity was found in T_3 (Silicon dioxide @ 120 kg ha^{-1}) followed by T_2 (Silicon dioxide @ 120 kg ha^{-1}) and minimum disease severity and occurred in applying T_1 (Silicon dioxide @ 60 kg ha^{-1}). Different doses of silicon dioxide were not significant on plant height and spike length. As a health status highest seed germination (98.54%), highest normal seedling (96.29%) was observed in the seeds which were cultivated with T_1 (Silicon dioxide @ 60 kg ha^{-1}) and highest dead seed (3.88%), abnormal seedling (5.50%) was observed in T_3 (Silicon dioxide @ 180 kg ha^{-1}). On the other hand, BWMRI Gom-1 showed higher seed germination (98.11%) than BWMRI Gom-2(96.56%). The interaction of T_1 (Silicon dioxide @ 60 kg ha^{-1}) and V_1 (BWMRI Gom -1) showed highest germination percentage (99.08%) and Normal seedling percentage (97.58%) than other treatment and variety combinations. Different pathogenic and non-pathogenic fungi were found associated with collected seed from treated plot with different doses of silicon dioxide. The following fungal pathogens, *Bipolaris sp., Fusarium sp., Aspergillus sp., Curvularia sp.*and *Colletotrichum* were found with wheat seeds. Treatment variety interaction showed maximum seed number was affected with *Bipolaris sorokiniana* at T_3V_2 (17.66%) and minimum at T_1V_1 (8.18%). As a treatment, maximum seed number was affected with *Bipolaris sorokiniana* was recorded from T_3 (16.50%) and minimum from T_1(10.13%). As a Variety, maximum seed number was affected with *Bipolaris sorokiniana* was recorded from BWMRI Gom-2 (14.78%) and minimum from BWMRI Gom-1 (10.92%). The results of the experiment revealed that as a variety the maximum grain yield (4.36 t ha^{-1}) was produced from V_1 (BWMRI Gom-1) and the lowest grain yield (3.79 t ha^{-1}) at V_2 (BWMRI Gom-2). As a treatment highest grain yield (4.72 t ha^{-1}) was obtained in T_1

(Silicon dioxide @ 60 kg ha^{-1}) and the lowest (3.47 t ha^{-1}) in T_3 (Silicon dioxide @ 180 kg ha^{-1}). Finally, highest grain yield (4.76 t ha^{-1}) was obtained from T_1V_1 interaction and the lowest was obtained (3.08 t ha^{-1}) at T_2V_3 interaction. So, in respect of growth characteristics, agronomic characters and major disease incidence and severity in field condition, the application of Silicon dioxide @ 60 kg ha^{-1} with BWMRI Gom -1 performed best as compared to the other treatments and variety. Prior to making a final recommendation, still, more detailed study on the compatibility of chemical compounds and the cost-benefit ratio of silicon dioxide application is required. To lessen the harmful effects of chemicals on the environment and human health, beneficial utilization of chemicals should be identified.

RECOMMENDATION

Silicon dioxide @ 60 kg ha^{-1} with BWMRI Gom-1 performed best during research period can be grown due to less disease infestation and resistance against *Bipolaris* leaf blight.

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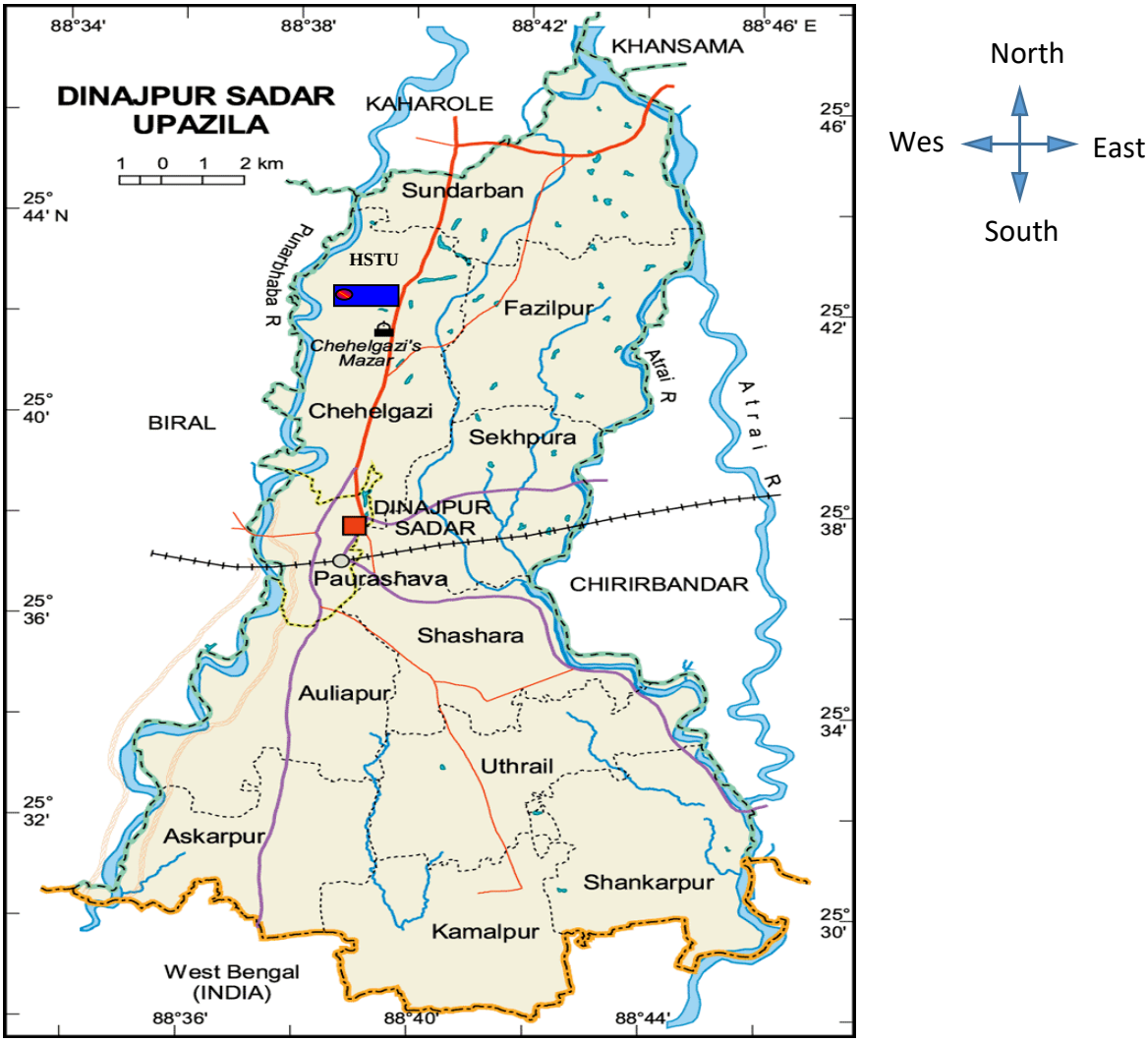
APPENDICES

Appendix I. Location of the experimental site (Map of Dinajpur Sadar Upazila showing the research field)



The geographical position of the experimental area and location is between 25°41'46.3"N and 88°39'01.1" E and 40 m above sea level

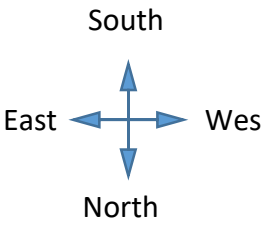
Appendix II. Soil physical and chemical properties of the experimental location

Parameters measured	Soil Layer between (0-40) cm
Soil textural classes	Sandy loam
Sand	47.60 %
Silt	36.00 %
clay	16.40 %
Organic matter	0.31 %
Organic carbon	0.18 %
Total N	0.007 %
Total P	14.30 %
Available K	0.05 $mgkg^{-1}$
Available S	18.09 $mgkg^{-1}$
Field capacity	10.50 %
CEC	1.00 Meq 100g
Ec	87.30 $mgkg^{-1}$
pH	6.12

Soil analysis was done from SRDI (Soil Resource Development Institute), Noshipur, Dinajpur, Bangladesh in December 2022.

Appendix III. Layout of experimental plot

Total plots=54
Replication=3
Treatment=3
Variety= 2



Replication 1		Replication 2		Replication 3	
T_1V_1	T_1V_2	T_1V_2	T_1V_1	T_2V_2	T_3V_1
T_1V_1	T_1V_2	T_1V_2	T_1V_1	T_2V_2	T_3V_1
T_1V_1	T_1V_2	T_1V_2	T_1V_1	T_2V_2	T_3V_1
T_2V_1	T_2V_2	T_3V_1	T_3V_2	T_3V_2	T_1V_2
T_2V_1	T_2V_2	T_3V_1	T_3V_2	T_3V_2	T_1V_2
T_2V_1	T_2V_2	T_3V_1	T_3V_2	T_3V_2	T_1V_2
T_3V_1	T_3V_2	T_2V_2	T_1V_1	T_1V_1	T_2V_1
T_3V_1	T_3V_2	T_2V_2	T_1V_1	T_1V_1	T_2V_1
T_3V_1	T_3V_2	T_2V_2	T_1V_1	T_1V_1	T_2V_1

T_1 = Silicon dioxide @ 60 kg ha^{-1}

T_2 = Silicon dioxide @ 120 kg ha^{-1}

T_3= Silicon dioxide @ 180 kg ha^{-1}

V_1 = BWMRI Gom -1

V_2 = BWMRI Gom -2

Appendix IV. Plates of some research field

Plate 1. Layout

Plate2. Seed sowing

Plate 3. Field visit with Prof. Dr. A.T.M. Shafiqul Islam

Plate 4. Plant height measuring

Plate 5. Field visit with Associate Prof. Dr. Shams Shaila Islam

Plate 6. Harvesting