EFFECT OF DIFFERENT LEVELS OF SEED INFECTION (*Bipolaris sorokiniana*) AND PLANT POPULATION DENSITY ON LEAF BLIGHT SEVERITY AND YIELD OF WHEAT

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This is to certify that thesis entitled, **"EFFECT OF DIFFERENT LEVELS OF SEED INFECTION (*Bipolaris sorokiniana*) AND PLANT POPULATION DENSITY ON LEAF BLIGHT SEVERITY AND YIELD OF WHEAT"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN PLANT PATHOLOGY,** embodies the result of a piece of *bona fide* research work carried out by **MD. NURUL ISLAM**, **Registration No. 09-03725** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

Dated: September 20, 2012
Place: Dhaka, Bangladesh

(Dr. F. M. Aminuzzaman)
Supervisor

Dedicated to

My

Beloved Parents

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September, 2012 **The Author**

SAU, Dhaka

EFFECT OF DIFFERENT LEVELS OF SEED INFECTION (*Bipolaris sorokiniana*) AND PLANT POPULATION DENSITY ON LEAF BLIGHT SEVERITY AND YIELD OF WHEAT

By

Md. Nurul Islam

ABSTRACT

The experiment was conducted during the period from May 2011 to April 2012 to find out the effect of seed infection levels and plant population density on leaf blight severity and yield of wheat. Three population density viz. 200 seed/m^2, 300 seed/m^2 and 400 seed/m^2 and six seed infection levels viz. 0%, 5.1 - 15%, 15.1 - 25%, 25.1 - 35%, 35.1 - 45% and 45.1-60% were used. Maximum leaf spot severity in flag leaf stage (0.36), panicle initiation stage (0.64), flowering stage (1.57), milk stage (1.84) and hard dough stage (2.30) was found in the interaction between sowing seeds @ 400 seeds/m^2 with 45.1-60% seed infection level. In every growth stage of the plant significantly lower leaf blight severity was recorded in the interaction between 200 seeds/m^2 with sowing of 0.0% infected seeds. Similar trends in disease severity were recorded on penultimate leaf in above mentioned growth stage. Significantly higher number of grains/ear (58.00) and healthy grains/ear (55.67) was recorded under the treatment T_1 (0% seed infection) with a seed rate of 200 seeds/m^2. Lower number of diseased grains/ear (2.33) were recorded under the treatments T_6 with 400 seeds/m^2 and T_1 with 200 seeds/m^2. Weight of diseased grains/ear ranged from 0.07 g to 0.75 g where the lowest value was recorded under T_1 X 200 seeds/m^2 treatment combination. Significantly higher (45.60) grain weight of 1000 seeds was recorded under the treatments T_1 (0% seed infection) with a seed rate of 200 seeds/m^2. Straw yield under different treatment combinations ranged from 3.17-4.21 t/ha where the highest straw yield was obtained under the treatment combination of T_1 X 200 seeds/m^2. Grain yield was significantly the highest (3.43 t/ha) when healthy seeds (0% infection) were sown @ 200 seeds/m^2.

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LIST OF ABBREVIATED TERMS

ABBREVIATION	FULL WORD
AEZ	Agro-Ecological Zone
et al.	And others
BARI	Bangladesh Agricultural Research Institute
BAU	Bangladesh Agricultural University
BSMRAU	Bangabondhu Sheikh Muzibur Rahman Agricultural University
CIMMYT	International Maize and Wheat Improvement Center
Cm^2	Centimeter Square
CV.	Cultivar
°C	Degree centigrade
CMI	Commonwealth Mycology Institution
DLB	*Drecheslera* leaf Blight
etc.	Etcetera
J.	Journal
No.	Number
LAD	Leaf Area Disease
LSD	Least Significant Difference
PDA	Potato Dextrose Agar
%	Percent
μ	Micrometer
R	Replication
Res.	Research
SAU	Sher-e-Bangla Agricultural University
SD	Standard Deviation

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1. Introduction

Wheat (*Triticum aestivum* L.) is the largest contributor with nearly 30% of the world grain production and 50% of the world grain trade. It is considered as the staple food crop of about two third of the world's population (Majumder, 1991) in as many as 43 countries and provides about 20% of the total food calories (Anon., 1986). The total world acreage of wheat was 60.43 million acres (USDA, 2008) with total production of about 608.1 million metric tones in the world in 2007-2008 (FAO, 2008). The consumption of wheat has been increasing during the last decade by about 5.6 million tons/year (Carter, 2002). The present yield potential of wheat is much lower than that of leading wheat growing countries.

At present, wheat was grown in an area of about 0.40 million hectares and the total production was 0.737 million metric tones in Bangladesh in 2007 (BBS, 2008). The average yield of wheat was 1.84 t/ha (BBS, 2008) which was lower than that of other countries in the world like U.K. (7.34 t/ha), Germany (7.10 t/ha), Netherlands (7.07 t/ha), China (4.78 t/ha) and Japan (3.9 t/ha) (FAO, 2008).

There are many factors responsible for lower yield of wheat in the country, use of unhealthy or diseased seeds are one of major constrains. And Population density significantly influenced the establishment of plant population and quality yield of wheat. For good crop and quality yield of wheat, good seed and optimum plant population are needed. Government and semi government organizations provided only 22.8% of the total requirement of wheat seed during 1998-1999 (Fakir, 1998). Those seeds are treated as quality seeds in Bangladesh. The rest 77.2% of the seeds produced traditionally by the farmers with no or little care even for purity and germination remain out of the scope of certification. As a result, a huge crop loss is incurred every year in wheat due to seed borne diseases in the country (Hossain, 2000).

Hossain *et al.,(*1998) reported that leaf blight caused by *Bipolaris sorokiniana* reduced yield up to 40% in field condition whereas Bazlur Rashid and Fakir (1998) recorded 57.6 and 64.5% yield reduction of wheat due to Bipolaris leaf blight in cvs. Kanchan and Sonalika, respectively. In severe condition, 100% yield loss of wheat may result (Hossain and Azad, 1994). Ahmed and Hossain (2005) found 43.75% yield loss in an inoculated wheat field. Gilchrist *et al.,*(1992) reported that the level of black point infection was independent of infection on leaves, spikes and nodes. No cultivars or genotypes have so far been found to possess high degree of resistance to black point disease caused by *Bipolaris sorokiniana* (Anon, 2002). Lower seed rate may reduce the yield drastically. Population densities significantly affect the yield of wheat. Optimum plant population ensures proper growth of the aerial and underground part of the plant through efficient utilization of solar radiation, nutrient uptake as well as air, space and water. The pathogen is seed borne and seed transmitted in nature and may exist in different parts of the seeds (Bazlur Rashid, 1998). Bipolaris leaf blight is a serious disease of wheat in the warmer areas of South Asia where spring wheat is grown during the winter season, November - April (Dubin and Duveiller, 2000). Fakir *et al.* (1977) first indicated the possibility of transmission of the pathogen through wheat seeds in Bangladesh. General observations indicate that Bipolaris leaf blight appears at the seedling stage (Alam *et al.*, 1994). In Bangladesh, higher trend of the disease was recorded with the increase in plant age under field condition (Nahar, 1995; Bazlur Rashid, 1997). The highest disease incidence has been reported to occur at the later stages of plant growth, particularly between flowering and grain filling (Wolf and Hoffman, 1994). Finally the pathogen attacks wheat grains causing black point. Hossain *et al.* (1998) reported that this disease reduced yield up to 40% in field condition whereas Bazlur Rashid and Fakir (1998) estimated 57.6 and 64.5% yield reduction of wheat due to Bipolaris leaf blight in cvs. Kanchan and Sonalika, respectively. In severe condition, 100% yield loss of wheat may result (Hossain and Azad, 1994). Ahmed and Hossain (2005) found 43.75% yield loss in an inoculated wheat field. Gilchrist *et al.* (1992) reported that the level of black point infection was independent of infection on leaves, spikes and nodes. No cultivars or genotypes have so far been found to possess high degree of resistance to black point disease caused particularly by *Bipolaris sorokiniana* (Anon. 2002). The percentages of seed infection increase in different plant density at all growth stages have a significant relation to determine the leaf blight incidence and severity caused by *Bipolaris sorokiniana.* Seed infection level had a significant effect on diseases incidence and severity at different growth stages like flag leaf stage, panicle initiation stage, flowering stage, milk stage and hard dough stage (Shah, *et al.* 1995). No agricultural system seems to be complete without the optimum plant population and level of seed infection. These factors can change the morphology and physiology of the growing plant and influence the growth and yield of the plant either directly or by the leaf blight/spot development of wheat (Ansar *et al.* 1996; Engelhard, 1989). The present study was undertaken to determine the potential contribution of *Bipolaris sorokiniana* to initiation of leaf blight/spot development and decreasing of quality yield of wheat. The objectives of the present research work were:

1) To determine the effect of different levels of seed infection by *Bipolaris sorokiniana* on growth, leaf blight severity and yield of wheat.

2) To study the effect of different plant population density on plant growth, leaf blight (*B. sorokiniana*) severity and yield of wheat.

3) To determine the interaction effect of seed infection by *B. sorokiniana* and plant population density on the plant growth, leaf blight severity and yield of wheat.

2. Review of literature

The effect of different levels of seed infection and plant population on leaf blight caused by *Bipolaris sorokiniana* and yield of wheat is reviewed in this chapter.

Machacek and Greaney (1938) reported from their greenhouse and field trials that seeds infected with *Helminthosporium sativum* produced only 24.8% plant stand and seedling disease rating on the plants revealed that when seed infected with *H. sativum* resulted 80% seedling infection.

Hanson and Christensen (1953) reported that wheat kernels infected with *Helminthosporium sativum* commonly germinated poorly and that in most cases, diseased seedlings resulted from such seed. Seeds infected with *Helminthosporium sativum* in the field produced 24% stands and 80.6% seedling disease for the plants from the seed containing *Helminthosporium sativum*.

Parashar and Chohan (1967) reported that 41.07% yield loss was incurred by sowing black pointed wheat seeds in the field.

Fakir *et., al.* (1977) reported the seed to plant transmission of *Drechslera sorokiniana* in wheat and they the importance and introduction of seed health testing program for wheat in Bangladesh has been reported.

Neergaard (1979) reported that *Bipolaris sorokiniana* were highly seed transmitted causing seedling blight, foot rot, ear blight of wheat.

Hampton (1980) found 35-37% infection of *Drechslera sorokiniana* from certified wheat seeds which were apparently healthy looking.

Bagga and Tomar (1981) conducted an experiment with three levels of planting densities viz. 200, 250 and 300 plants /m^2 in the field and they reported that 1000 grain weight remained unaffected by reduction in plant population of wheat.

Rana and Gupta (1982) reported that black point infections greatly affected not only seed germination but also the root and shoot growth of the seedlings where the effect was very prominent on root growth.

Chaudhary *et., al.* (1984) observed maximum of 44.67% reduction in germination of diseased wheat seeds in blotter method and 16% in pots. The invasion of pathogen on plumule and coleoptile might be impairing the germination, as lesions have been noticed in the young plumule and protruding out from diseased seeds.

Sinha and Thapliyal (1984) found maximum reduction of 38% seed germination of wheat seed infested with black pointed pathogen.

Frank (1985) and Lin (1985) recorded 6.2 - 29 % reduction in seedling stand of winter wheat due to seed borne infection of *Bipolaris sorokiniana*.

Saari (1985) reported that the high level of kernel infection has major implications on seedling blight, or damping off if the infected seeds are used for sowing.

Gaffer and Shahidullah (1985) conducted an experiment to study the effect of seed rates on the performance of wheat cv. Inia-66 and they used

three levels of seed rates such as 100, 140 and 180 kg/ha. Plant height was significantly higher at 100 kg seeds/ha than the other rates.
Schmidt (1986) reported that, sowing of black pointed wheat seeds at various infestation levels had no effect on plant stand, yield and transmission of the disease to the subsequent crops in Bangladesh.

Khanum *et al.,* (1987) stated that black point is responsible for the failure of germination of a high percentage of grains in the field. Visual observations indicated that natural infection of grains of the cultivars was Lyp-73, Pari-73 and Pak-81 was 50%, 35% and 15%, respectively. The germination of healthy grains was 55-96.5% and that of diseased grains 34.5-71 %.

Fakir (1988) observed that in Bangladesh no significant effect of sowing 0.6 to 12% black point affects the seeds on the yield, incidence of seedling blight or leaf blight and development of black point in the harvested grains. He reported that reduction in germination of black point affected seeds was directly related with the severity of infection.

Endres and Joba (1989) reported that the highest grain yield was achieved at the highest sowing rate of wheat.

Zhang *et al.,* (1990) observed that 1000 grain weight of black pointed grains infected by *Bipolaris sorokiniana* was 1.95 - 13.50% lower than uninfected grains.

Roy and Biswas (1991) carried out an experiment with 100, 200, 300, 400, 500 and 600 seeds/m^2 to study the effect of population on tillering, growth, yield components and yield of wheat and they observed that there was no significant effect among the seed rates on plant height.

Reis (1991) reported that the transmission rate of *Bipolaris sorokiniana* from infected seed to the coleoptile was about 2 :1.

Mishra (1993) carried out a field trial where three seed rate viz. 100, 125 and 150 kg seeds/ha was used as experimental treatment and an average grain yield of 1.24, 1.37 and 1.28 t/ha was obtained, respectively.

The effect of seed rates on the performance of different high yielding varieties of wheat using three seed rates (80, 100, 120 kg/ha) and four varieties (Akbar, Barkat, Ananda and Kanchan) were included in the study where the length of spike decreased with the increase of seed rate (Torofder, 1993).

Rashid *et al.* (1994) reported that the seed quality deterioration is positively associated with the incidence of leaf blight caused by *Bipolaris sorokiniana* under field conditions.

Ahmed *et al.* (1995) studied on two cultivars using seeding rates from 40-120 kg seed/ha and revealed that 1000 grains weight decreased from 40.47 to 39.69 g with the corresponding seeding rates.

Bulson *et al.* (1997) reported that the grain yield of sole-cropped wheat increased up to the full recommended density and declined slightly at increased plant population.

Rashid *et al.* (1997) showed gradual reduction in germination of wheat seed with the increases of seed infection level. There was a trend of decrease in seed germination with the increases in seed borne infection.

Hossain (2000) reported that seed sample having 28% black pointed seed resulted maximum reduction in germination by 20.20% and 42.69% in the blotter and rolled paper towel method and emergence by 34.27% and 40.74% in the field and in the pot, respectively. The higher level of black point infection in the seed sample incited more disease to the crop plants resulting formation of higher number of diseased seed in the field.

Mozumder (2001) used three seed rate namely 75, 100 and 125 kg /ha and he obtained longest spike of 8.98 cm produced from the treatment of 75 kg seed/ha which was followed by 8.76 and 8.40 cm obtained from the seed rate of 100 and 125 kg/ha.

Arif *et al.* (2002) studied the effect of four seed rates (50, 100, 120 and 150 kg /ha) of wheat cv. Inqilab-91 and Bakhtawar-92 in the experiment. Maximum plant height (97 cm) was recorded at sowing rates of 150 kg seeds/ha.

Das (2002) used three levels of planting density (500, 250 and 188 seeds/m^2) of wheat cv. kanchan and concluded that planting density did not significantly influence plant height. The highest plant height was observed in density of 188 seeds/m^2.

The initial plant population, spike length, grains/spike, 1000 seed weight and grain yield significantly influenced by seed rate. The higher number of spikes m^2 was obtained with 100 kg seed rate ha. The highest grain yield of 4.16 t/ha in 2001-2002 and 4.20 t/ ha in 2002-2003 was observed at 100 and 120 seed rate/ha respectively in both the years there were no statistical difference between the seed rates (Talukdar *et al.*, 2004).

Fazli *et al.* (2004) conducted a three successive year (1990-1991 to 1992-1993) study program to determine the effect of sowing date, seed rate and weed control method on grain yield and yield components of bread wheat. Seed rate 100 kg/ha significantly increased grains/spike, 1000 grain weight and grain yield. The highest seed rates of 150 kg/ha produced the maximum number of spikes m^2 compared to others.

Dixit and Gupta (2004) carried out an experiment to determine the effect of seed rate (100, 125 and 150 kg/ha) on growth and the yield of wheat and they found that increasing seed rate significantly reduced the spike length and increased the plant height.

Reza *et al.* (2006) reported that the maximum seed rot/seedling mortality (15.73%) followed by subsequent leaf blight severity (75.4%) was recorded as a result of sowing 30% infected seeds while the minimum (5%) infected seeds resulted in 3.1% and 57.53% of seed rot/seedling mortality and leaf blight severity, respectively. They also found that 65.36 percent disease severity interning the corresponding 17.42 percent seed infection.

Chowdhury *et al.* (2009) reported that seed germination, seedling growth and vigor index decreased and abnormal and infected seedlings increased gradually with the increased level of seed infection of wheat.

Chowdhury *et al.* (2010) also reported that leaf blight severity of wheat was increased with the increasing level of seed infection. They also reported that weight of grains/ear and weight of healthy grains/ear significantly increased with decreasing of seed infection level.

Begum (2010) conducted an experiment to find out the effect of six different levels of seed infection and three population density of wheat on leaf blight severity and healthy seed production of wheat cv. Shatabdi. She reported that population density and seed infection levels had significant influence on plant growth, leaf blight development, yield and yield contributing character. Leaf blight severity was increased with the increasing levels of seed infection. The highest grain yield (3.14 t/ha) was obtained using healthy seeds whereas grain yield was lowest (1.04 t/ha) when 45.1 to 60.0% infected seeds were sown.

3. Materials and Methods

The experiment was conducted in the laboratory, net house and field laboratory of the Department of Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka during the period from May 2011 to April 2012.

3.1. Laboratory experiment

The Laboratory experiment was conducted in the disease diagnostic Laboratory, Department of Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka during the period of January 2011 to June 2011.

3.1.1. Planting Material

Leaf blight susceptible variety Sonalika was used in this study.

3.1.2. Collection of seeds

Seeds were collected from Bangladesh Agricultural Research Institute and the collected seeds were kept in brown paper envelope and was stored in refrigerator at $4^{O}C$.

3.1.3. Preparation of different treatments

Different treatments were prepared following Begum (2010). The seed sample was physically sorted out to prepare different level of seed infection. Six levels of seed infection was prepared to determine the development of leaf blight/spot by *Bipolaris sorokiniana* of wheat.

Firstly, black pointed seeds were separated from healthy looking golden colored seed by manual seed sorting. Secondly, different level of seed infection was prepared by mixing of healthy seeds and black pointed seeds in different proportion and the levels of seed infection were confirmed by subsequent laboratory seed health Blotter test (ISTA, 1996).

3.1.4. Treatments

Six treatments were used in this experiment. These treatments were as follows:

T_1= (0% seed infection)

T_2= (5.1 - 15% seed infection)

T_3= (15.1 - 25% seed infection)

T_4 = (25.1 - 35% seed infection)

T_5= (35.1 - 45% seed infection)

T_6= (45.1- 60%seed infection)

3.1.5. Tray method of seedling symptom and vigor test

Seedling symptom and vigor test was done using plastic tray following the method of Begum, 2010. In this method, 200 seeds were randomly taken from each treatment maintaining three replications. Plastic tray was filled with mixed soil (soil+ cow dung + sand) previously sterilized by formalin. Four lines were made in each tray where 50 seeds were sown in each line. After 15 days data were recorded on germination, number of healthy seedling, number of infected seedling, shoot length, root length, shoot and root weight following ISTA rules (1996).

3.2. Field experiment

3.2.1. Experimental site and experimental period

The experiment was conducted in the field laboratory, Department of Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka during the rabi season from May 2011 to April 2012.

3.2.2. Climate of experimental site

The experimental area was under the subtropical climate which is characterized with the comparatively high rainfall, high humidity, high temperature, relatively long day during April to September and scanty rainfall, low humidity, low temperature and short day period during October to April. The later period (November-April) is favorable for wheat cultivation. Monthly air temperature, relative humidity (%) and total rainfall (mm) and average sunshine hour of site during the experimental period have been shown in Appendix -1.

3.2.3. Treatments

The treatments were as follows:

(A) Main plot

200 seed/m^2

300 seed/m^2

400 seed/m^2

(B) Sub plot

T_1 = 0% seed infection

T_2 = 5.1 - 15% seed infection

T_3 = 15.1 - 25% seed infection

T_4 = 25.1 - 35% seed infection

T_5 = 35.1 - 45% seed infection

T_6 = 45.1- 60% seed infection

3.2.4. Soil

The soil of the experimental site belongs to the agro - ecological region of Madhupur Tract, AEZ - 28. It was Deep Red Brown Terrace Soil and belongs to "Nodda" cultivated soil series. The soil was silty clay loam in texture. Organic matter content was very low (0.82%) and soil pH was 5.55. The physical and chemical characteristics of soil have been shown below:

Total N %	0.078
Organic matter %	0.88
Phophorus %	0.0015
Potassium %	0.0053
Sulphur %	0.0017

The description of the Agro-ecological zone (UNDO and FAO, 1988) and soil properties of the experimental site was as follows :

- Agro-ecological region: Madhupur Tract (AEZ-28)
- Land Type: Medium High Land
- General soil type: Non-Calcareous Dark gray floodplain soil
- Soil propreties : Tejgaon
- Topography: Up land
- Elevation: 8.45
- Location: SAU Farm, Dhaka
- Field level: Above flood level
- Drainage: Fairly good
- Fairness (Consistency): Compact to friable when dry.

3.2.5. Experimental design and layout

The experiment was laid out in split-plot design with three replications. The experimental unit was divided into three blocks. Each block was divided into three main plots in which different population density was assigned randomly. Each main plot was further divided into six sub-plots where different levels of seed infection was allotted randomly. The total number of unit plots in the entire experiment was $3\times3\times6 = 54$. Size of each unit plot was 2 m×1.5 m. The distance between sub-plot was 0.5 m and block was 1 m.

3.2.6. Land Preparation

The experimental field was thoroughly ploughed and cross ploughed and cleaned prior to seed sowing and application of fertilizers and manure was done in the field. The experimental field was prepared by thorough ploughing followed by laddering to have a good tilth. Finally, the land was properly leveled before seed sowing.

3.2.7. Applications of fertilizers

The field was fertilized at the rate of 220 Kg Urea, 180 Kg TSP, 50 Kg MP, 120 Kg Gypsum and 10 tons Cow dung per hectare (Krishi Projukti Hatbooi, 2005). Two third of Urea, full dose of TSP, MP, Gypsum and Cow dung was applied at the time of final land preparation. Remaining one third of Urea was applied at 25 days after seed sowing.

3.2.8. Sowing of seeds

Wheat seeds were sown in the field on 20th November, 2011 and the seeds were placed continuously in lines properly at a depth of 5 cm and were covered by soil with the help of hand. The distance between lines was 25 cm which made 6 rows in each unit plot.

3.2.9. Intercultural operations

Weeds were controlled thoroughly. Three weedings were done at 25, 50 and 75 DAS. The weeds were eradicated by nirani followed by a light irrigation for proper germination.

3.2.10. Plant protection activities

Special care was taken for 15 days after sowing to protect the crop from birds especially at sowing and germination stages and at the ripening stage of the crop.

3.2.11. Tagging and data collection

Randomly five plants were selected from each row of the plot and tagged. So, a total of 30 plants/plot were tagged for rating and mean values were determined to get rating score of each treatment.

3.2.12. Isolation and identification of pathogen

The leaf blight causal organism *Bipolaris sorokiniana* was isolated following tissue planting method. The diseased leaves were collected and were taken to the laboratory. The leaves were then cut into about 0.5 cm) small pieces with diseased and healthy portion and surface sterilized with $HgCl_2$ solution (0.01%) for 30 second. The cut pieces were then washed in water at three times and were placed onto PDA. The plates were then incubated at 25±1°C for 7 days. Later the pathogen was purified using hyphal tip culture method and grown on PDA media at 25±1°C for two weeks and identified as *Bipolaris sorokiniana* (Plate 1 and Plate 2) following the key of Mathur and Kongsdal (2004).

3.2.13. Evaluation of leaf blight severity

Leaf blight severity of flag leaf and penultimate leaf was determined in five growth stages of plant namely flag leaf stage, panicle initiation stage, flowering stage, milk stage and hard dough stage. The leaf blight severity was determined following 0-5 grade of Hossain and Azad,1992 (Fig. 3.) where:

0	=	No infection (Highly resistant)
1	=	Few minute lesions on leaves (Resistant)
2	=	Black lesion with no distinct chlorotic halos covering ≤10% of the leaf area (Moderately resistant)
3	=	Typical lesions surrounded by distinct chlorotic halos covering 10-50%of the leaf area (Moderately susceptible)
4	=	Severe lesions on leaves with ample necrotic zones drying over part of the leaf, covering ≥50 % of the leaf (Susceptible)
5	=	Severe infection, drying of the leaf, spike infected to some extend (Highly susceptible)

3.2.14. Harvesting of crop

The crop was harvested at full ripening stage on 3 April, 2012.

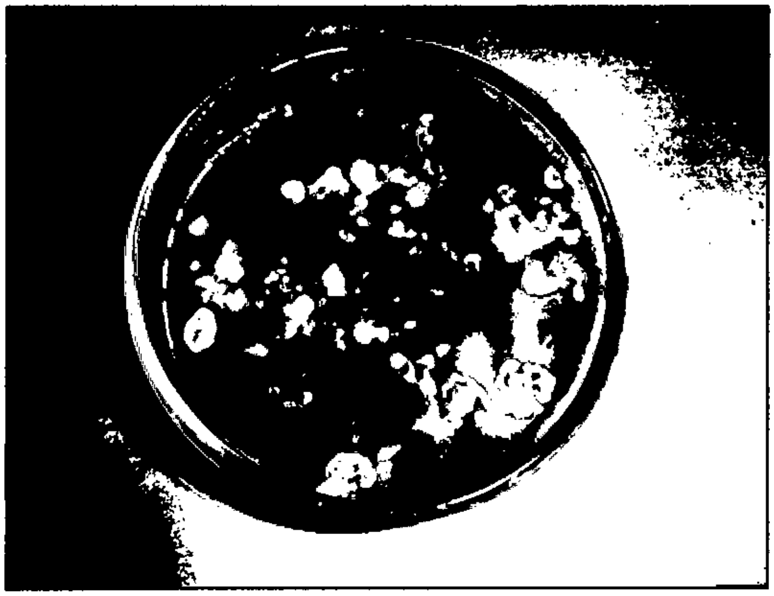

Plate 1. Pure culture of *Bipolaris sorokiniana*

Plate 2. Conidia of *Bipolaris sorokiniana* (X40)

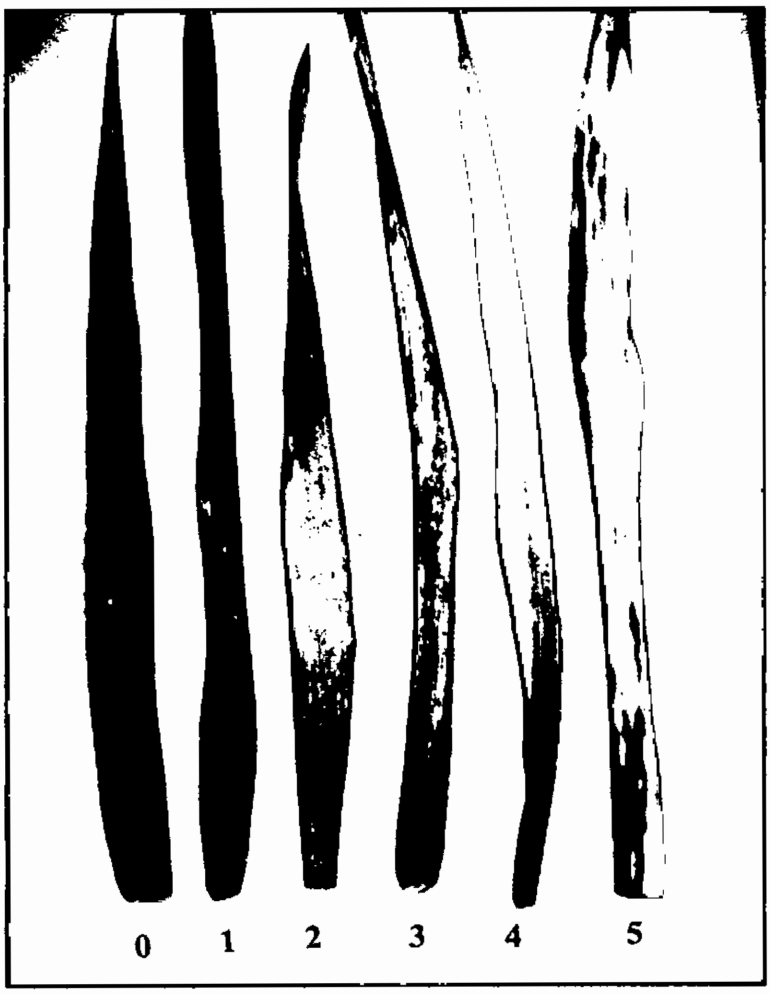

Plate 3. 0-5 scale of leaf blight severity

3.2.15. Collection of data on yield and yield contributing characters

Data of plant growth and yield contributing characters was recorded from the randomly selected 35 tagged plants of each unit plot on the following parameters:

- Plant height (cm)
- Length of ear (cm)
- Number of spikelets/ear
- Number of healthy spikelets/ear
- Number of diseased spikelets/ear
- Number of grains/ear
- Number of healthy grains/ear
- Number of diseased grains/ear
- Weight of grains/ear
- Weight of healthy grains/ear (g)
- Weight of diseased grains/ear (g)
- 1000 grain weight (g)
- Straw yield/plot (kg)
- Straw yield (t/ha)
- Grain yield/plot (kg)
- Grain yield (t/ha)

3.3. Statistical analysis

The collected data for different parameters were compiled and tabulated in proper form. Appropriate statistical analysis was made by MSTAT Computer Package program. The treatment means were compared by Duncan's Multiple Range Test (DMRT).

4. Results

4.1. Net house experiment

4.1.1. Effect of different levels of seed infection (*Bipolaris sorokiniana*) on seed germination and seedling stand of wheat seedling in the tray soil

Seedling emergence under different treatments varied from 32.0 – 60% (Fig. 1.). The highest emergence (60%) was counted in T_1 (0% seed infection) followed by T_2 (53.0%), T_3 (51.0%) and T_4 (42.0%) and the lowest seedling emergence (32.0%) was observed in T_6 (45.1-60% seed infection). Percent healthy seedling production varied from 30.0 – 54.0 % (Fig. 2). Maximum healthy seedling production (54.0%) was counted in T_1 (0% seed infection) followed by T_2 (50.0%), T_3, (48.0%) T_4 (43.0%) and T_5 (40.0%). Minimum healthy seedling production (only 30.0%) was observed in T_6 (45.1-60% seed infection).

In respect of seedling infection, the results varied from 10.0%- 29.0% (Fig. 3). The maximum (29.0%) count of seedling infection was found in T_6 (45.1-60% seed infection) followed by T_5 (18.0%) and the minimum (10.0%) count of seedling infection was recorded in T_1 (0% seed infection).

Root length varied from 22.3 -33.0 cm (Fig. 4). The maximum root length (33.0 cm) was recorded in T_1 (0% seed infection) followed by T_2 (31.5 cm) and T_3 (30.8 cm) and the minimum (22.3 cm) result was found in T_6 (45.1-60% seed infection).

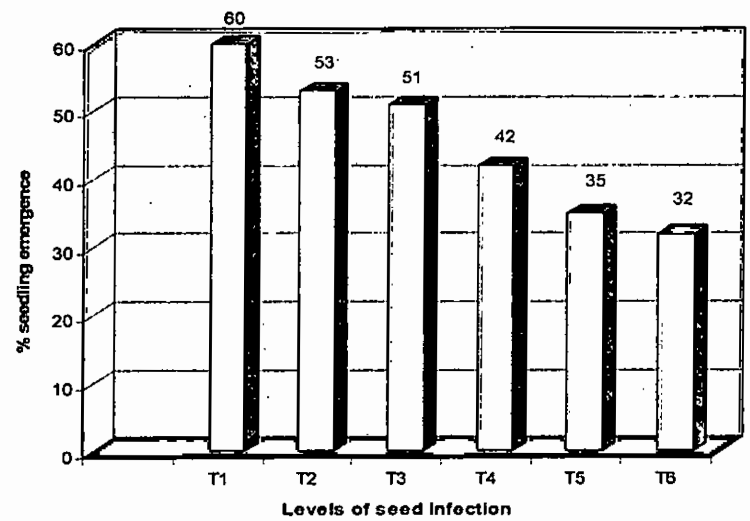

Fig. 1. Effect of different levels of seed infection by *B. sorokiniana* on % seedling emergence of wheat cv.sonalika in tray soil

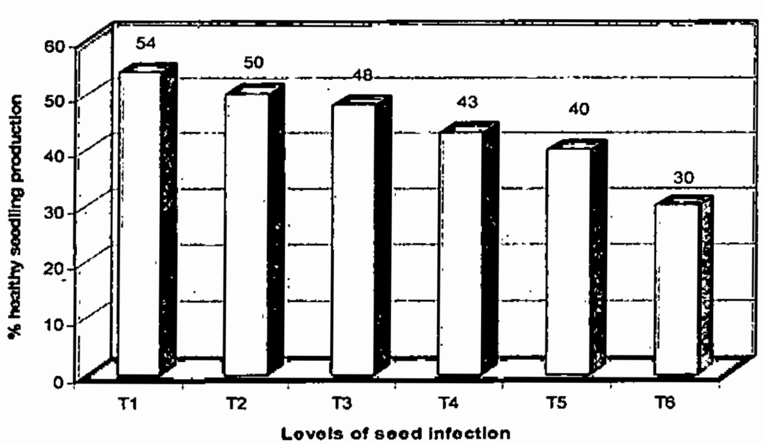

Fig. 2. Effect of different levels of seed infection by *B. sorokiniana* on % healthy seedling production of wheat cv. sonalika in tray soil

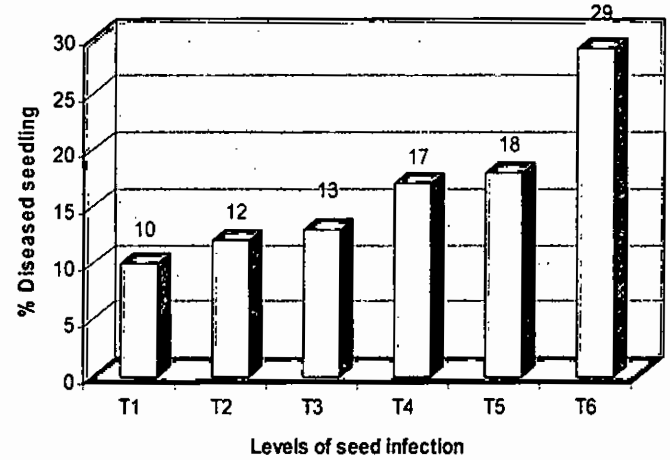

Fig. 3. Effect of different levels of seed infection by *B. sorokiniana* on % diseased seedling production of wheat cv. sonalika in tray soil

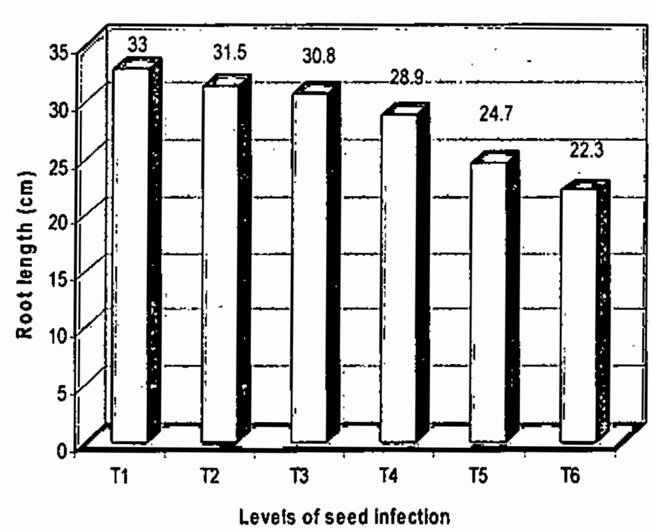

Fig. 4. Effect of different levels of seed infection by *B. sorokiniana* on root length of wheat cv. sonalika grown in tray soil

The shoot length varied from 21.30 -28.0 cm (Fig. 5). The maximum shoot length (28.30 cm) was recorded in T_1 (0% seed infection) followed by T_2 (27.0 cm), T_3 (26.3 cm) and the minimum (21.3 cm) shoot length was recorded in T_6 (45.1-60% seed infection). Root weight/seedling varied from 0.8-1.3 g (Fig. 6) where the highest (0.8 g) root weight was found in T_1 (0% seed infection) followed by T_2 (1.1 g) and T_3 (1.0 g). On the other hand, the lowest (0.8 g) value was observed in T_6 (45.1-60% seed infection).

Considering shoot weight, the values ranged from 3.1-3.6 g (Fig. 7). The lowest shoot weight/plant (3.1 g) was found in T_6 (45.1-60% seed infection) and the highest weight (3.6 g) was found in T_1 (0% seed infection).

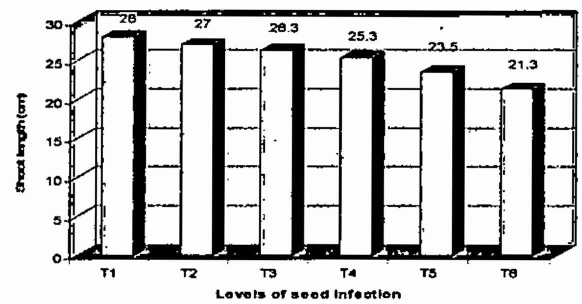

Fig. 5. Effect of different levels of seed infection by B. sorokiniana on shoot length of wheat seedlings cv. sonalika grown in tray soil

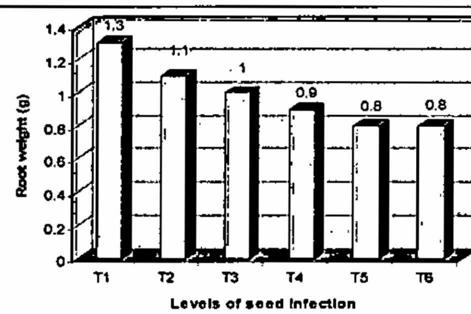

Fig. 6. Effect of different levels of seed infection by *B. sorokiniana* on root weight of wheat seedlings cv. sonalika grown in tray soil

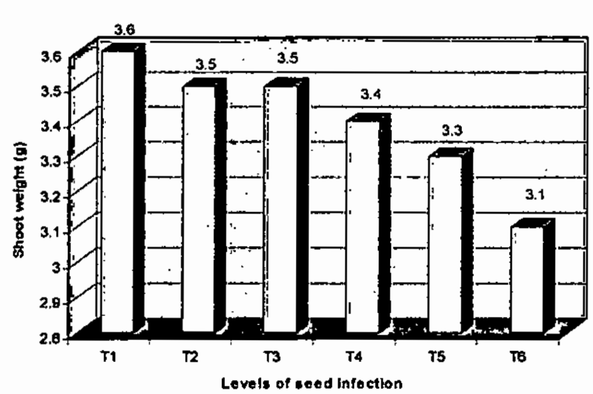

Fig. 7. Effect of different levels of seed infection by *B. sorokiniana* on shoot weight of wheat seedlings cv. sonalika grown in tray soil

4.2. Field experiment

4.2.1. Effect of population density on the severity of leaf blight on flag leaf of wheat at different growth stages

Effect of population density and different levels of seed infection by *B. sorokiniana* on leaf blight severity on flag leaf of wheat cv. sonalika are shown in Table 1. The highest flag leaf spot severity in flag leaf (0.21), panicle initiation (0.44), flowering (1.43), milking (1.62) and hard dough stage (1.94) was recorded when 400 seeds/m^2 were sown. Leaf blight severity was lower in all the above mentioned growth stages of the crop when seeds were sown @ 200 seeds/m^2.

4.2.2. Effect of different levels of seed infection on the severity of leaf blight on flag leaf of wheat at different growth stages

Leaf spot severity differed significantly among different levels of seed infection in different growth stages of the crops (Table 1). The highest flag leaf spot severity in flag leaf (0.33), panicle initiation (0.60), flowering (1.44), milking (1.66) and hard dough stage (1.98) was recorded under the treatment T_6 (45.1-60% seed infection). Significantly lower leaf blight severity was recorded in T_1 (0% seed infection) in every growth stage of the crop.

4.2.3. Interaction effect of population density and different levels of seed infection on leaf blight severity of wheat on flag leaf at different growth stages

Interaction effect between different levels of seed infection and plant population density on flag leaf spot development by *Bipolaris sorokiniana* of wheat at different growth stages are significant and shown in Table 2. Maximum leaf spot severity in flag leaf stage (0.36), panicle initiation stage (0.64), flowering stage (1.57), milking stage (1.84) and hard dough stage (2.30) was found in the interaction between sowing seeds @ 400 seeds/m^2 with T_6 (45.1-60% seed infection). In every growth stage of the plant significantly lower leaf spot severity was recorded in the interaction between 200 seeds/m^2 with sowing of 0.0% (T_1) infected seeds.

Table 1. Effect of population density and different levels of seed infection by *B. sorokiniana* on leaf blight severity on flag leaf of wheat cv sonalika

Population density (seeds/m^2)	Disease severity in different growth stage				
	Flag leaf	Panicle initiation	Flowering	Milking	Hard dough
200	0.15 c	0.31 a	1.16 a	1.31 a	1.51 a
300	0.19 b	0.40 a	1.28 a	1.36 a	1.67 a
400	0.21 a	0.44 a	1.43 a	1.62 a	1.94 a
Seed infection (%)					
T_1=(0.0)	0.05 f	0.21 e	1.10 a	1.24 c	1.47 d
T_2=(5.1-15.0)	0.10 e	0.27 de	1.16 a	1.31 bc	1.57 cd
T_3=(15.1-25.0)	0.15 d	0.33 cd	1.21 a	1.39 bc	1.64 bcd
T_4=(25.1-35.0)	0.22 c	0.41 bc	1.27 a	1.46 abc	1.74 abc
T_5=(35.1-45.0)	0.27 b	0.47 b	1.56 a	1.53 ab	1.85 ab
T_6=(45.1-60.0)	0.33 a	0.60 a	1.44 a	1.66 a	1.98 a

Table 2. Interaction effect of population density and different levels of seed infection by *B. sorokiniana* on leaf blight severity on flag leaf of wheat cv. sonalika

Population density (seeds/m^2)	Levels of seed infection (%)	Disease severity in different growth stage				
		Flag leaf	Panicle initiation	Flowering	Milking	Hard dough
200	T_1=(0.0)	0.02 p	0.15 j	1.00 c	1.12 i	1.29 j
	T_2=(5.1-15.0)	0.06 n	0.19 ij	1.06 c	1.18 hi	1.37 ij
	T_3=(15.1-25.0)	0.12 k	0.27 gh	1.13 bc	1.28 ghi	1.47 hij
	T_4=(25.1-35.0)	0.18 h	0.32 fg	1.18 bc	1.34 e-i	1.53 ghi
	T_5=(35.1-45.0)	0.24 f	0.37 ef	1.30 bc	1.42 d-g	1.64 d-h
	T_6=(45.1-60.0)	0.30 c	0.55 bc	1.28 bc	1.52 b-f	1.77 c-f
300	T_1=(0.0)	0.05 o	0.22 hij	1.12 bc	1.14 hi	1.46 hij
	T_2=(5.1-15.0)	0.11 l	0.27 ghi	1.18 bc	1.23 ghi	1.58 f-i
	T_3=(15.1-25.0)	0.14 i	0.33 fg	1.23 bc	1.33 f-i	1.61 e-h
	T_4=(25.1-35.0)	0.23 g	0.44 de	1.29 bc	1.36 e-h	1.71 d-g
	T_5=(35.1-45.0)	0.29 d	0.51 cd	1.38 bc	1.45 c-g	1.78 c-f
	T_6=(45.1-60.0)	0.33 b	0.60 ab	1.47 bc	1.62 bcd	1.85 cd
400	T_1=(0.0)	0.07 m	0.27 ghi	1.17 bc	1.46 c-g	1.65 d-h
	T_2=(5.1-15.0)	0.13 j	0.35 fg	1.23 bc	1.51 b-f	1.76 c-g
	T_3=(15.1-25.0)	0.18 h	0.38 ef	1.27 bc	1.56 b-e	1.83 cde
	T_4=(25.1-35.0)	0.25 e	0.48 cd	1.35 bc	1.67 abc	1.97 bc
	T_5=(35.1-45.0)	0.29 d	0.54 bc	2.00 a	1.73 ab	2.12 ab
	T_6=(45.1-60.0)	0.36 a	0.64 a	1.57 b	1.84 a	2.30 a

4.2.4. Effect of population density on the severity of leaf blight on penultimate leaf of wheat at different growth stages

Effect of population density and different levels of seed infection by *B. sorokiniana* on leaf blight severity on penultimate leaf of wheat cv sonalika are shown in Table 3. The highest penultimate leaf spot severity in flag leaf stage (0.52), panicle initiation stage (0.94), flowering stage (2.85), milking stage (2.96) and hard dough stage (3.29) was recorded when 400 seeds/m^2 were sown. Leaf blight severity was lower in all the above mentioned growth stages of the crop when seeds were sown @ 200 seeds/m^2.

4.2.5. Effect of different levels of seed infection on the severity of leaf blight on penultimate leaf of wheat at different growth stages

Leaf blight severity on penultimate leaf differed significantly among different levels of seed infection in different growth stages of the crops (Table 3). The highest flag leaf spot severity in flag leaf (0.65), panicle initiation (1.04), flowering (2.94), milking (2.97) and hard dough stage (3.68) was recorded under the treatment T_6 (45.1-60% seed infection). Significantly lower leaf blight severity was recorded in T_1 (0% seed infection) in every growth stage of the crop.

4.2.6. Interaction effect of population density and different levels of seed infection on leaf blight severity of wheat on penultimate leaf at different growth stages

Interaction effect between different levels of seed infection and plant population density on penultimate leaf blight development by *Bipolaris sorokiniana* of wheat at different growth stages are significant and shown in Table 4. Maximum leaf blight severity in flag leaf stage (0.74), flowering stage (3.34), milking stage (3.34) and hard dough stage (3.87) was found by sowing 45.1-60% infected seeds @ 400 seeds/m^2. In every growth stage of the plant significantly lower leaf spot severity was recorded in the interaction between 200 seeds/m^2 with sowing of 0.0% (T_1) infected seeds.

Table 3. Effect of population density and different levels of seed infection by *B. sorokiniana* on leaf blight severity on penultimate leaf of wheat cv sonalika

Population density (seeds/m^2)	Disease severity in different growth stage				
	Flag leaf	Panicle initiation	Flowering	Milking	Hard dough
200	0.35 b	0.76 a	2.31 b	2.43 b	2.94 a
300	0.43 ab	0.92 a	2.64 ab	2.45 b	3.18 a
400	0.52 a	0.94 a	2.85 a	2.96 a	3.29 a
Seed infection (%)					
T_1=(0.0)	0.22 e	0.65 b	2.25 c	2.35 c	2.65 e
T_2=(5.1-15.0)	0.32 d	0.74 ab	2.37 c	2.48 c	2.84 de
T_3=(15.1-25.0)	0.40 c	0.82 ab	2.50 bc	2.57 bc	3.05 cd
T_4=(25.1-35.0)	0.47 bc	0.91 ab	2.70 ab	2.55 bc	3.21 bc
T_5=(35.1-45.0)	0.53 b	1.08 a	2.84 a	2.78 ab	3.41 ab
T_6=(45.1-60.0)	0.65 a	1.04 a	2.94 a	2.97 a	3.68 a

Table 4. Interaction effect of population density and different levels of seed infection by *B. sorokiniana* on leaf blight severity of penultimate leaf of wheat cv. sonalika

Population density (seeds/m^2)	Levels of seed infection (%)	Disease severity in different growth stage				
		Flag leaf	Panicle initiation	Flowering	Milking	Hard dough
200	T_1=(0.0)	0.18 i	0.55 f	2.03 i	2.11 l	2.48 i
	T_2=(5.1-15.0)	0.24 jh	0.59 f	2.19 hi	2.30 jkl	2.75 hi
	T_3=(15.1-25.0)	0.31 f	0.70 def	2.26 gh	2.40 h-k	2.85 gh
	T_4=(25.1-35.0)	0.40 e	0.81 def	2.34 fgh	2.48 f-j	2.96 fhg
	T_5=(35.1-45.0)	0.45 de	0.92 a-e	2.45 fg	2.57 e-i	3.19 def
	T_6=(45.1-60.0)	0.52 c	0.98 a-d	2.55 ef	2.72 c-f	3.39 cd
300	T_1=(0.0)	0.21 hi	0.61 ef	2.31 gh	2.27 jkl	2.68 hi
	T_2=(5.1-15.0)	0.31 f	0.77 def	2.46 fg	2.34 ijkl	2.80 gh
	T_3=(15.1-25.0)	0.39 e	0.84 c-f	2.56 ef	2.41 g-k	3.07 efg
	T_4=(25.1-35.0)	0.45 e	0.95 a-d	2.69 de	2.20 kl	3.29 cde
	T_5=(35.1-45.0)	0.51 cd	1.13 abc	2.89 cd	2.65 d-h	3.47 cd
	T_6=(45.1-60.0)	0.69 ab	1.22 a	2.94 c	2.83 cd	3.77 ab
400	T_1=(0.0)	0.28 fg	0.78 def	2.41 fgh	2.66 d-g	2.77 h
	T_2=(5.1-15.0)	0.41 e	0.84 c-f	2.46 fg	2.78 cde	2.95 fgh
	T_3=(15.1-25.0)	0.51 cd	0.92 a-e	2.68 de	2.90 bcd	3.22 def
	T_4=(25.1-35.0)	0.56 c	0.98 a-d	3.03 bc	2.98 bc	3.36 cd
	T_5=(35.1-45.0)	0.64 b	1.18 ab	3.17 ab	3.12 ab	3.57 bc
	T_6=(45.1-60.0)	0.74 a	0.91 b-e	3.34 a	3.34 a	3.87 a

4.2.7. Effect of population density on plant growth and spikelet formation of wheat

Plant height, ear length and distance between flag leaf and base of ear under different population density did not differ significantly (Table 5). Significantly higher number of spikelets/ear (17.36) and healthy spikelets/ear (16.06) was obtained when seeds were sown @ 200 seeds/m^2. On the other hand significantly higher number of diseased spikelets/ear was recorded under 400 seeds/m^2.

4.2.8. Effect of different levels of seed infection by *Bipolaris sorokiniana* on plant growth and spikelet formation of wheat

Plant height, ear length and distance from the flag leaf initiation and base of the ear did not differ significantly under different levels of seed infection (Table 5).

The plant height ranged from 96.76 cm -103.3 cm where the maximum plant height was obtained at T_1 (0% Seed infection) and the minimum plant height was obtained at T_6 (45.1-60% seed infection) though there was no significant difference among them. Similar trends of different levels of seed infection effects were obtained on ear length and distance between flag leaf and base of ear. Significantly higher number of spikelets/ear (17.32) and healthy spikelets/ear (16.29) was obtained when seeds were sown @ 200 seeds/m^2. On the other hand significantly higher number of diseased spikelets/ear (2.97) was recorded under 400 seeds/m^2.

Table 5. Effect of population density and different levels of seed infection by *B. sorokiniana* on plant growth and spikelet formation of wheat cv sonalika

Population density (seeds/m^2)	Plant height (cm)	Ear length (cm)	Distance between flag leaf and base of ear (cm)	No. of spikelets/ ear	No. of healthy spikelets / ear	No. of diseased spikelets/ ear
200	102.2 a	17.44 a	18.74 a	17.36 a	16.06 a	1.33 b
300	101.4 a	16.53 a	17.62 a	16.61 ab	15.33 a	1.37 b
400	98.74 a	15.40 a	15.77 a	15.29 b	12.21 b	3.09 a
Seed infection (%)						
T_1=(0.0)	103.3 a	17.09 a	19.01 a	17.32 a	16.29 a	1.03 d
T_2=(5.1-15.0)	102.7 a	16.93 a	18.38 a	17.04 ab	15.61 ab	1.44 cd
T_3=(15.1-25.0)	101.8 a	16.61 a	17.91 a	16.65 abc	14.92 bc	1.76 bcd
T_4=(25.1-35.0)	101.0 a	16.22 a	15.84 a	16.17 bcd	14.21 c	1.96 bc
T_5=(35.1-45.0)	99.23 a	16.06 a	16.84 a	15.94 cd	13.77 c	2.41 ab
T_6=(45.1-60.0)	96.76 a	15.86 a	16.27 a	15.38 d	12.41 d	2.97 a

4.2.9. Interaction effect of population density and different levels of seed infection on plant growth and spikelet formation of wheat

The combined effect of population density and different levels of seed infection on plant growth and spikelet formation of wheat are shown in Table 6. Significantly higher plant growth (105.0 cm), ear length (18.17 cm), distance between flag leaf and base of ear (20.50 cm), number of spikelets/ ear (18.33) and number of healthy spikelets/ear (17.83) was recorded when healthy seeds (0% seed infection) were sown @ 200 seeds/m^2. On the other hand all the above mentioned parameters values were lower when maximum levels of infected seeds (45.1-60.0% seed infection) were sown @ 400 seeds/m^2 except the number of diseased spikelets/ear.

Table 6. Interaction effect of population density and different levels of seed infection by *B. sorokiniana* on plant growth and spikelet formation of wheat cv sonalika

Population density (seeds/m^2)	Levels of seed infection (%)	Plant height (cm)	Ear length (cm)	Distance between flag leaf and base of ear (cm)	No. of spikelets/ ear	No. of healthy spikelets/ ear	No. of diseased spikelets/ ear
200	T_1=(0.0)	105.0 a	18.2	20.50 a	18.33 a	17.83 a	0.50 j
	T_2=(5.1-15.0)	104.0 b	18.0	20.00 ab	18.00 ab	17.00 a-c	1.00 h-j
	T_3=(15.1-25.0)	102.8 d	17.4	19.30 abc	17.37 b-d	16.07 c-e	1.30 g-i
	T_4=(25.1-35.0)	102.1 f	17.1	18.43 abc	16.90 c-f	15.37 e-g	1.53 f-h
	T_5=(35.1-45.0)	101.0 i	17.0	17.47 abc	17.00 c-e	15.60 d-f	1.57 f-h
	T_6=(45.1-60.0)	98.53 l	17.0	16.77 abc	16.57 d-g	14.50 gh	2.07 d-f
300	T_1=(0.0)	103.5 c	17.1	19.40 abc	17.63 a-c	17.23 ab	0.40 j
	T_2=(5.1-15.0)	103.1 d	16.9	18.07 abc	17.30 b-e	16.40 b-d	0.90 ij
	T_3=(15.1-25.0)	102.4 e	16.8	17.53 abc	16.87 c-f	15.50 d-g	1.37 g-i
	T_4=(25.1-35.0)	101.7 g	16.2	17.32 abc	16.43 e-g	15.07 e-g	1.37 g-i
	T_5=(35.1-45.0)	99.97 j	16.1	16.93 abc	16.03 f-h	14.7 f-h	1.87 e-g
	T_6=(45.1-60.0)	97.67 m	16.0	16.45 abc	15.37 hi	13.07 ij	2.30 de
400	T_1=(0.0)	101.4 h	16.0	17.13 abc	16.00 f-h	13.80 hi	2.20 de
	T_2=(5.1-15.0)	101.0 i	15.9	17.07 abc	15.83 gh	13.43 i	2.43 c-e
	T_3=(15.1-25.0)	100.0 j	15.6	16.90 abc	15.72 gh	13.18 i	2.60 cd
	T_4=(25.1-35.0)	99.17 k	15.4	11.78 d	15.17 hi	12.20 j	2.97 c
	T_5=(35.1-45.0)	96.73 n	15.0	16.13 bc	14.80 ij	11.00 k	3.80 b
	T_6=(45.1-60.0)	94.10 o	14.5	15.60 c	14.20 j	9.67 l	4.53 a

4.2.10. Effect of population density on grain formation and grain weight of wheat

Effect of population density on grain formation and grain weight of wheat are shown in Table 7. Number of grains/ear and number of healthy grains/ear under different population density were significant. Higher number of grains/ear (53.14) and healthy grains/ear (49.33) were recorded under the population density of 200 seeds/m^2. On the other hand significantly lower number of grains/ear (45.75) and healthy grains/ear (40.72) was recorded under the population density of 400 seeds/m^2. Similar trends were found in weight of grains/ear and weight of healthy grains/ear. Considering number of diseased grains/ear and weight of diseased grains/ear the effect of different population densities were insignificant.

4.2.11. Effect of different levels of seed infection on grain formation and grain weight of wheat

Effect of different levels of seed infection on grain formation and grain weight of wheat are shown in Table 7. Number of grains/ear and number of healthy grains/ear under different levels of seed infection were Statistically similar. Significantly higher number of grains/ear (53.33) and healthy grains/ear (50.56) was recorded under the treatment T_1 (0% seed infection). On the other hand significantly lower number of grains/ear (43.59) and healthy grains/ear (37.39) was recorded under the treatment T_6 (45.1-60% seed infection). Similar trends were found in weight of grains/ear and weight of healthy grains/ear. Significantly higher number of diseased grains/ear (5.53) and lower number of diseased grains/ear (2.78) were recorded under the treatments T_6 and T_1, respectively. Considering the weight of diseased grains/ear the effect of different levels of seed infections were insignificant.

Table 7. Effect of population density and different levels of seed infection by *B. sorokiniana* on grain formation and grain weight of wheat cv sonalika

Population density (seeds/m^2)	No. of grains/ear	No. of healthy grains/ear	No. of diseased grains/ear	Weight of grains/ear (g)	Weight of healthy grains/ear (g)	Weight of diseased grains/ear (g)
200	53.14 a	49.33 a	3.88 a	2.81 a	2.61 a	0.12 a
300	47.72 ab	44.14 b	3.58 a	2.53 ab	2.34 ab	0.11 a
400	45.75 b	40.72 b	4.69 a	2.45 b	2.16 b	0.43 a
Seed infection (%)						
T_1=(0.0)	53.33 a	50.56 a	2.78 d	2.83 a	2.89 a	0.08 a
T_2=(5.1-15.0)	51.39 ab	47.92 ab	3.47 cd	2.72 ab	2.50 ab	0.11 a
T_3=(15.1-25.0)	49.76 abc	46.01 bc	3.86 bc	2.64 abc	2.44 bc	0.23 a
T_4=(25.1-35.0)	48.63 bc	44.46 cd	4.20 bc	2.57 bc	2.36 cd	0.26 a
T_5=(35.1-45.0)	46.51 cd	42.04 d	4.47 b	2.53 c	2.23 d	0.28 a
T_6=(45.1-60.0)	43.59 d	37.39 e	5.53 a	2.31 d	2.98 e	0.36 a

4.2.12. Interaction effect of population density and different levels of seed infection on grain formation and grain weight of wheat

The combined effect of population density and different levels of seed infection on grain formation grain weight of wheat are significant and shown in Table 8. Significantly higher number of grains/ear (58.00) and healthy grains/ear (55.67) was recorded under the treatment T_1 (0% seed infection) with a seed rate of 200 seeds/m^2. On the other hand significantly lower number of grains/ear (41.50) and healthy grains/ear (33.10) was recorded under the treatment T_6 (45.1-60% seed infection) with a sowing rate of 400 seeds/m^2. Similar trends were found in weight of grains/ear and weight of healthy grains/ear. Significantly higher number of diseased grains/ear (6.40) and lower number of diseased grains/ear (2.33) were recorded under the treatments T_6 with 400 seeds/m^2 and T_1 with 200 seeds/m^2, respectively. Weight of diseased grains/ear ranged from 0.07 g to 0.75 g where the highest and lowest values were recorded under T_6 X 400 seeds/m^2 and T_1 X 200 seeds/m^2 treatment combinations, respectively.

Table 8. Interaction effect of population density and different levels of seed infection by *B. sorokiniana* on grain formation and grain weight of wheat cv sonalika

Population density (seeds/m^2)	Levels of seed infection (%)	No. of grains/ear	No. of healthy grains/ear	No. of diseased grains/ear	Weight of grains/ear (g)	Weight of healthy grains/ear (g)	Weight of diseased grains/ear (g)
200	T_1=(0.0)	58.00 a	55.67 a	2.33 ij	3.07 a	2.95 a	0.07 d
	T_2=(5.1-15.0)	56.33 ab	52.83 b	3.50 f-h	2.98 ab	2.80 b	0.11 b-d
	T_3=(15.1-25.0)	53.83 bc	50.17 cd	4.00 e-g	2.85 bc	2.66 cd	0.12 b-d
	T_4=25.1-35.0)	52.67 cd	48.63 de	4.10 d-f	2.77 cd	2.58 de	0.13 b-d
	T_5=35.1-45.0)	50.67 de	46.33 e-g	4.33 c-e	2.68 de	2.46 e-g	0.13 b-d
	T_6=45.1-60.0)	47.33 fg	42.33 ij	5.00 bc	2.51 fg	2.24 ij	0.16 b-d
300	T_1=(0.0)	53.33 cd	51.33 bc	2.00 j	2.83 cd	2.74 bc	0.06 d
	T_2=(5.1-15.0)	50.50 de	47.67 ef	2.83 hi	2.68 de	2.52 d-f	0.09 cd
	T_3=(15.1-25.0)	48.50 ef	45.23 f-h	3.27 gh	2.57 ef	2.39 f-h	0.10 b-d
	T_4=25.1-35.0)	46.80 fg	42.87 h-j	3.93 e-g	2.48 fg	2.27 h-j	0.10 b-d
	T_5=35.1-45.0)	45.23 gh	41.00 jk	4.23 c-f	2.40 g	2.18 jk	0.14 b-d
	T_6=45.1-60.0)	41.93 i	36.73 l	5.20 b	2.23 h	1.95 l	0.16 b-d
400	T_1=(0.0)	48.67 ef	44.67 g-i	4.00 e-g	2.58 ef	2.37 g-i	0.12 b-d
	T_2=(5.1-15.0)	47.33 fg	43.27 h-j	4.07 d-f	2.51 fg	2.29 h-j	0.13 b-d
	T_3=(15.1-25.0)	46.93 fg	42.63 h-j	4.30 c-f	2.48 fg	2.26 h-j	0.48 a-d
	T_4=25.1-35.0)	46.43 f-h	41.87 j	4.57 b-e	2.46 fg	2.22 j	0.55 a-c
	T_5=35.1-45.0)	43.63 hi	38.80 kl	4.83 b-d	2.49 fg	2.06 kl	0.57 ab
	T_6=45.1-60.0)	41.50 i	33.10 m	6.40 a	2.18 h	2.15 m	0.75 a

4.2.13. Effect of population density on 1000 seed weight and yield of wheat

Effect of population density on 1000 seed weight and yield of wheat are shown in Table 9. 1000-seed weight, straw yield and grain yield under different population density were statistically similar. 1000-seed weight ranged from 42.40 g to 44.38 g where highest and lowest 1000-seed weight were recorded under the seed rate of 200 and 400 seeds/m^2, respectively. Similar trends were recorded in straw and grain yield of wheat where higher straw and grain yield (3.82 and 3.12 t/ha, respectively) and lower straw and grain yield (3.58 and 2.92 t/ha, respectively) was recorded under the population density of 200 seeds/m^2 and 400 seeds/m^2, respectively.

4.2.14. Effect of different levels of seed infection on 1000 seed weight and yield of wheat

Effect of levels of seed infection on 1000 seed weight and yield of wheat are shown in Table 9. 1000-seed weight under different seed infection levels was statistically similar. But straw yield and grain yield were significant under different levels of seed infection. 1000-seed weight ranged from 41.67 g to 44.77 g where highest and lowest 1000-seed weight were recorded under the treatment of T_1 and T_6, respectively. Similar trends were recorded in straw and grain yield of wheat where higher straw and grain yield (4.05 and 3.31 t/ha, respectively) and lower straw and grain yield (3.12 and 3.31 t/ha, respectively) was recorded under the treatment of T_1.

Table 9. Effect of population density and different levels of seed infection by *B. sorokiniana* on 1000 seed weight and yield of wheat cv sonalika

Population density (seeds/m^2)	1000 seed weight (g)	Straw yield (t/ha)	Grain yield (t/ha)
200	44.38 a	3.82 a	3.12 a
300	43.43 a	3.55 a	2.90 a
400	42.40 a	3.58 a	2.92 a
Seed infection (%)			
T_1=(0.0)	44.77 a	4.05 a	3.31 a
T_2=(5.1-15.0)	44.20 a	3.92 ab	3.20 ab
T_3=(15.1-25.0)	43.83 a	3.75 abc	3.08 abc
T_4=25.1-35.0)	43.23 a	3.59 bcd	2.94 bcd
T_5=35.1-45.0)	42.73 a	3.39 cd	2.77 cd
T_6=45.1-60.0)	41.67 a	3.18 d	2.60 d

4.2.15. Interaction effect of population and different levels of seed infection on 1000 seed weight and yield of wheat

Combined effect of population density and different levels of seed infection on 1000 seed weight and yield of wheat are shown in Table 10. 1000-seed weight, straw yield and grain yield under different population density and levels of seed infections differed significantly. Significantly higher (45.60) and lower (40.50) 1000-grain weight was recorded under the treatments T_1 (0% seed infection) with a seed rate of 200 seeds/m^2 and under the treatment T_6 (45.1-60% seed infection) with a sowing rate of 400 seeds/m^2, respectively. Straw yield under different treatment combinations ranged from 3.17-4.21 t/ha where highest and lowest straw yield was obtained under the treatment combination of T_1 X 200 seeds/m_2 and T_6 X 400 seeds/m^2, respectively. Similar trends were found in grain yield where significantly higher grain yield (3.43 t/ha) was recorded when healthy seeds (0% infection) were sown @ 200 seeds/m^2. On the other hand lower grain yield (2.58 t/ha) was recorded when maximum levels of infected seeds (45.1-60.0% seed infection) were sown @ 400 seeds/m^2.

Table 10. Interaction effect of population density and different levels of seed infection by *B. sorokiniana* on plant growth and spikelet formation of wheat cv sonalika

Population density (seeds/m^2)	Levels of seed infection (%)	1000 seed weight (g)	Straw yield (t/ha)	Grain yield (t/ha)
200	T_1=(0.0)	45.60 a	4.21 a	3.43 a
	T_2=(5.1-15.0)	45.10 ab	4.08 ab	3.35 ab
	T_3=(15.1-25.0)	44.80 ab	3.91 a-e	3.20 a-e
	T_4=25.1-35.0)	44.20 a-c	3.75 b-f	3.08 b-f
	T_5=35.1-45.0)	43.70 a-c	3.59 d-g	2.93 d-h
	T_6=45.1-60.0)	42.90 a-c	3.35 g-j	2.75 g-j
300	T_1=(0.0)	44.80 ab	4.00 a-c	3.27 a-c
	T_2=(5.1-15.0)	44.20 a-c	3.87 a-e	3.15 a-f
	T_3=(15.1-25.0)	43.90 a-c	3.69 c-g	3.03 c-g
	T_4=25.1-35.0)	43.30 a-c	3.47 f-i	2.85 f-i
	T_5=35.1-45.0)	42.80 a-c	3.21 h-j	2.60 h-j
	T_6=45.1-60.0)	41.60 bc	3.03 j	2.47 j
400	T_1=(0.0)	43.90 a-c	3.95 a-d	3.21 a-d
	T_2=(5.1-15.0)	43.30 a-c	3.80 b-f	3.10 b-f
	T_3=(15.1-25.0)	42.80 a-c	3.64 c-g	3.02 c-g
	T_4=(25.1-35.0)	42.20 a-c	3.55 e-h	2.89 e-h
	T_5=(35.1-45.0)	41.70 a-c	3.37 g-j	2.75 g-j
	T_6=(45.1-60.0)	40.50 c	3.17 ij	2.58 ij

5. DISCUSSION

Effect of different levels of seed infection by *Bipolaris sorokiniana* and population density on leaf blight severity and yield of wheat have been conducted under net house and field condition. There were six treatments with different levels of seed infection by *Bipolaris sorokiniana* were used in the subplot namely T_1 = 0% seed infection, T_2 = 5.1-15% infection, T_3 = 15.1-25% infection, T_4 = 25.1-35% infection, T_5 = 35.1-45% infection and T_6 = (45.1-60% infection). Three population density namely 200 seeds/m^2, 300 seeds/m^2 and 400 seeds/m^2 were used in the main plot.

In the net house tray soil maximum seedling emergence was found under 0% infected seeds (T_1). With the increase of seed infection, remarkable decreasing of the seedling emergence was recorded and lowest emergence was recorded in seeds with the maximum (45.1-60%) infection (T_6).

Hanson and Christensen (1953) found 66% and 62% seed germination by sowing seeds having 81% and 74% seed infection, respectively, with *Helminthosporium sativum*. Choudhary *et al.* (1984) reported that germination of the black pointed seeds both in laboratory and green house pot soil was found to decrease by 11.6% and 16.0%, respectively. Hossain (2000) reported that maximum reduction of germination was found by 20.20% and 42.69% in blotter and rolled paper towel method, respectively in 28% black pointed seeds. Reduction in germination of wheat seeds due to black point infection was also recorded by other previous workers (Parashar and Chohan, 1967; Rana and Gupta, 1982; Sinha *et al.* 1984 and Zhang *et al.*, 1990).

From the present study, it was revealed that different levels of seed infection by *Bipolaris sorokiniana* had significant relationship with seedling infection as well as seedling health. Seedling infection increased with the increasing level of seed infection in net house tray soil. Maximum number of infected seedling (9.0%) was recorded in T_6 (45.1-60% infection), where maximum number of healthy seedlings (54.0%) were counted under seed sowing of 0.0% infected seeds. Root length, shoot length, root weight and shoot weight also decreased with increasing the levels of seed infection by *B. sorokiniana*.

The findings of the present study are supported Begum (2010) and Chowdhury (2009). Begum (2010) reported that %number of infected seedlings and % dead seed was higher at maximum (45.1-60.0%) levels of seed infection and lower at 0% seed infection level. Chowdhury (2009) also found a tendency of increasing seedling infection and decreasing vigor index of wheat seedlings with increasing levels of seed infection by *B. sorokiniana*. Rana and Gupta (1982) found that black point infection greatly affected root and shoot growth of the seedlings, the effect being very prominent on root growth.

Considering main effect of different levels of seed infection by *B. sorokiniana* it has been found that leaf blight severity on flag leaf and penultimate leaf in flag leaf stage, panicle initiation stage, flowering stage, milk stage and hard dough stage was gradually increased with increasing levels of seed infection. Higher leaf blight severity was recorded when maximum levels of infected seeds i.e. 45.1-60.0% infected seeds were sown. On the other hand leaf blight severity was minimum in all the growth stage recorded when healthy seeds (0.0% infected) were sown. Considering population density it has been found that leaf blight severity in all the growth stages were higher when seeds were sown @ 400 seeds/m^2. When interaction effect between levels of seed infection and population density was taken under consideration it has been found that the disease severity was always significantly higher in maximum levels of infected seeds (45.1-60.0% infected) sown in the plot @ 400 seeds/m^2. Significantly lower leaf blight severity was recorded under plots of 0.0% infected seeds sown @ 200 seeds/m^2. More or less similar field experiment was carried out by Begum (2010). She also found the increasing tendency of leaf blight severity of wheat with increasing levels of seed infection and plant population density. But she obtained two different kinds of reaction of leaf blight of wheat cv shatabdi. She found maximum leaf blight severity in flag leaf stage and panicle initiation stage when 400 seeds of maximum levels of infection (45.1-60.0%) were sown. But in flowering, milk and hard dough stage the leaf blight severity was higher in plots of 300 seeds/m^2 with maximum levels of infected seeds. In the present study leaf blight susceptible variety sonalika was used as a test crop and in all the growth stages the disease severity was always higher in maximum levels of infected seeds (45.1-60.0%) with high population density (400 seeds/m^2) of the seeds. Thus leaf blight severity not only dependent on the interaction between population density and levels of seed infection but some other factors like variety, position of leaf, growth stage of the crop, environmental factors and sowing time might have some impact on leaf blight development. Hossain (2000) reported higher the level of seed borne fungal infection, there will be higher primary inoculum level in the field resulted higher infection in the field. He also found that the maximum infection severity was attained at hard dough stage due to the favorable temperature range 25-28°C for disease epidemy in March when the plants turn to soft dough to hard dough stage. Reza *et al.* (2006) found that the maximum seed infection level gave rise the highest disease severity in adult plants.

The main effect of different levels of seed infection and population density on plant growth was not significant but their interaction effect was significant regarding plant growth parameters. The effect of plant population was also given by Ansar (2010) who mentioned the density treatments increased there was a progressive increase in plant height. The values recorded were 78.6, 74.4 and 69.2 cm for plants growing in tiller densities of 600, 120 and 300 seeds/ m^2, respectively. This report was also similar to the findings of Chatha *et al.* (1986); Dixit *et al.* (2004). They reported that there was no significant influence among the seed rate on plant height.

The maximum seed infection (T_6) and maximum population density resulted the lowest number of healthy spikelets/ear but the highest number of diseased spikelets/ear. The opposing trend was observed in T_1 (0% seed infection). Begum (2010) found similar results where maximum seed infection resulted lowest number of spikelets/ear and healthy spikelets/ear but highest number of diseased spikelets/ear.

In the present study number of grains/ear, number of healthy grains/ear, weight of grains/ear and weight of healthy grains/ear was always higher in lower population density (200 seeds/m^2) and minimum seed infection (0.0%) level. In the interaction effect lower population density X minimum seed infection resulted higher value of the above parameters. The opposite trends were found in number and weight of diseased grains/ear. Dixit and Gupta (2004) observed population density had a significant relation with grain formation and stated that increasing the sowing rate significantly reduced the number of grains/spike. Kabir (2006) also reported that seed rate had significant influence on number of grains/spike. Hossain *et al.* (1998) observed that leaf infection at flowering stages has direct effect on the reduction of formation of healthy grains with the increase in number of black pointed as well as discolored grains. Rashid and Fakir (1998) reported that shriveled grain and black pointed kernel symptoms have been recorded as the effect of seed to plant to seed transmission of *Bipolaris sorokiniana*. Hossain (2000) found that the higher level of black point infection in the seed sample incited more disease to the crop plants resulting formation of higher number of diseased seed in the field.

In the present study population density and different levels of seed infection had no significant effect on weight of thousand seeds. Kabir (2006) reported that the 1000 grain weight did not differ significantly due to different seed rate of wheat. Begum (2010) also did not find significant effect of population density but she reported that the effect was significant for different levels of seed infection. In interaction effect significantly higher 1000 seed weight was obtained in lower population density (200 seeds/m^2) X minimum seed infection (0.0%) that was statistically similar with lower infection X both of the higher population density. But in a previous study Begum (2010) reported a tendency of increasing 1000 seed weight with increasing the population density i.e. the results differed from this study. Grain yield as well as straw yield were found in maximum amount in T_1 (0% seed infection) whereas, the minimum yields were obtained in T_6 having maximum seed infection. Grain yield also higher (3.12 t/ha) in minimum population density which decreased with increasing population density. In interaction effect higher yield (3.43 t/ha) was obtained when 0.0% infected seeds were sown @ 200 seeds/m^2. On the other hand significantly lower grain yield (2.58 t/ha) was recorded in higher infection level with 400 seeds/m^2. Chowdhury *et al.* (2010) obtained highest grain yield of wheat by using 0.0% infected seeds which was 38.69% increased over the result of using 45.1-60.0% infected seeds. The findings of this study differed in comparing the findings of the previous studies where Begum (2010) found comparatively higher grain yield (3.28 t/ha) in the plot where 0.0% infected seeds were sown @ 400 seeds/m^2.

6. Summary and Conclusion

The experiment was conducted in net house and farm of Sher-e-Bangla Agricultural University, Dhaka to determine the effect of different levels of seed infection by *B. sorokiniana* and plant population density on leaf blight disease and yield of wheat.

Three population density namely 200 seed/m^2, 300 seed/m^2 and 400 seed/m^2 were used in the main plot where six seed infection levels namely 0% seed infection, 5.1 - 15% seed infection, 15.1 - 25% seed infection, 25.1 - 35% seed infection, 35.1 - 45% seed infection and 45.1-60% seed infection levels were used in sub plot as treatments.

In the net house tray soil test the highest seedling emergence (60%) was counted in 0.0% seed infection and the lowest seedling emergence (32.0%) was observed in 45.1-60% seed infection. Maximum healthy seedling (54.0%) was counted in 0.0% seed infection and minimum healthy seedlings (30.0%) was recorded in 45.1-60% seed infection levels. The highest (29.0%) count of seedling infection was recorded in 45.1-60% seed infection and the minimum (10.0%) count of seedling infection was recorded in 0.0% seed infection. Root length, shoot length, root weight and shoot weight also found higher in 0.0% infected seeds.

The highest flag leaf spot severity in flag leaf (0.21), panicle initiation (0.44), flowering (1.43), milk (1.62) and hard dough stage (1.94) was recorded when 400 seeds/m^2 were sown. Leaf blight severity was lower in all the above mentioned growth stages of the crop when seeds were sown @ 200 seeds/m^2. On the other hand maximum flag leaf spot severity in flag leaf stage (0.33), panicle initiation (0.60), flowering (1.44), milk

(1.66) and hard dough stage (1.98) was found under the treatment T_6 (45.1-60% seed infection). Significantly lower leaf blight severity was recorded in T_1 (0% seed infection) in every growth stage of the crop. Maximum leaf spot severity in flag leaf stage (0.36), panicle initiation stage (0.64), flowering stage (1.57), milk stage (1.84) and hard dough stage (2.30) was found in the interaction between sowing seeds @ 400 seeds/m^2 with 45.1-60% seed infection level. In every growth stage of the plant significantly lower leaf blight severity was recorded in the interaction between 200 seeds/m^2 with sowing of 0.0% infected seeds.

The highest penultimate leaf spot severity in flag leaf stage (0.52), panicle initiation stage (0.94), flowering stage (2.85), milk stage (2.96) and hard dough stage (3.29) was recorded when 400 seeds/m^2 were sown. Leaf blight severity was lower in all the above mentioned growth stages of the crop when seeds were sown @ 200 seeds/m^2. The highest penultimate leaf spot severity in flag leaf (0.65), panicle initiation (1.04), flowering (2.94), milk (2.97) and hard dough stage (3.68) was recorded under the treatment T_6 (45.1-60% seed infection). Significantly lower leaf blight severity was recorded in T_1 (0% seed infection) in every growth stage of the crop. Maximum leaf blight severity of penultimate leaf in flag leaf stage (0.74), flowering stage (3.34), milk stage (3.34) and hard dough stage (3.87) was found by sowing 45.1-60% infected seeds @ 400 seeds/m^2. In every growth stage of the plant significantly lower leaf spot severity was recorded in the interaction between 200 seeds/m^2 with sowing of 0.0% (T_1) infected seeds.

Significantly higher number of spikelets/ear (17.36) and healthy spikelets/ear (16.06) was obtained when seeds were sown @ 200 seeds/m^2. On the other hand significantly higher number of diseased spikelets/ear was recorded under 400 seeds/m^2.

The plant height ranged from 96.76 cm -103.3 cm where the maximum plant height was obtained at T_1 (0% Seed infection) and the minimum plant height was obtained at T_6 (45.1-60% seed infection) though there was no significant difference among them. Similar trends of different levels of seed infection effects were obtained on ear length and distance between flag leaf and base of ear. Significantly higher number of spikelets/ear (17.36) and healthy spikelets/ear (16.06) was obtained when seeds were sown @ 200 seeds/m^2. On the other hand significantly higher number of diseased spikelets/ear (3.09) was recorded under 400 seeds/m^2. Significantly higher plant growth (105.0 cm), ear length (18.17 cm), distance between flag leaf and base of ear (20.50 cm), number of spikelets/ ear (18.33) and number of healthy spikelets/ear (17.83) was recorded when healthy seeds (0% seed infection) were sown @ 200 seeds/m^2. On the other hand all the above mentioned parameters were lower when maximum levels of infected seeds (45.1-60.0% seed infection) were sown @ 400 seeds/m^2 except the number of diseased spikelets/ear.

Number of grains/ear and number of healthy grains/ear under different population density were significant. Higher number of grains/ear (53.14) and healthy grains/ear (49.33) was recorded under the population density of 200 seeds/m^2. On the other hand significantly lower number of grains/ear (45.75) and healthy grains/ear (40.72) was recorded under the population density of 400 seeds/m^2. Similar trends were found in weight of grains/ear and weight of healthy grains/ear. Considering number of diseased grains/ear and weight of diseased grains/ear the effect of different population densities were insignificant.

Number of grains/ear and number of healthy grains/ear under different levels of seed infection were significant. Significantly higher number of grains/ear (53.33) and healthy grains/ear (50.56) was recorded under the treatment T_1 (0% seed infection). On the other hand significantly lower number of grains/ear (43.59) and healthy grains/ear (37.39) was recorded under the treatment T_6 (45.1-60% seed infection). Similar trends were found in weight of grains/ear and weight of healthy grains/ear. Significantly higher number of diseased grains/ear (5.53) and lower number of diseased grains/ear (2.78) were recorded under the treatments T_6 and T_1, respectively. Considering the weight of diseased grains/ear the effect of different levels of seed infections were insignificant.

Significantly higher number of grains/ear (58.00) and healthy grains/ear (55.67) was recorded under the treatment T_1 (0% seed infection) with a seed rate of 200 seeds/m^2. On the other hand significantly lower number of grains/ear (41.50) and healthy grains/ear (33.10) was recorded under the treatment T_6 (45.1-60% seed infection) with a sowing rate of 400 seeds/m^2. Similar trends were found in weight of grains/ear and weight of healthy grains/ear. Significantly higher number of diseased grains/ear (6.40) and lower number of diseased grains/ear (2.33) were recorded under the treatments T_6 with 400 seeds/m^2 and T_1 with 200 seeds/m^2, respectively. Weight of diseased grains/ear ranged from 0.07 g to 0.75 g where the highest and lowest values were recorded under T_6 X 400 seeds/m^2 and T_1 X 200 seeds/m^2 treatment combinations, respectively.

Thousand seed weight, straw yield and grain yield under different population density were statistically similar. Thousand seed weight ranged from 42.40 g to 44.38 g. The highest (44.38 g) and lowest (42.40 g) 1000-seed weight was recorded under the seed rate of 200 and 400 seeds/m^2, respectively. Similar trends were recorded in straw and grain yield of wheat where the highest straw and grain yield (3.82 and 3.12 t/ha, respectively) and lower straw and grain yield (3.58 and 2.92 t/ha, respectively) was recorded under the population density of 200 seeds/m^2 and 400 seeds/m^2, respectively.

Thousand seed weight under different seed infection levels was statistically similar. But straw yield and grain yield were significant under different levels of seed infection. 1000-seed weight ranged from 41.67 g to 44.77 g where highest and lowest 1000-seed weight were recorded under the treatment of T_1 and T_6, respectively. Similar trends were recorded in straw and grain yield of wheat where higher straw and grain yield (4.05 and 3.31 t/ha, respectively) and lower straw and grain yield (3.12 and 3.31 t/ha, respectively) was recorded under the treatment of T_1.

Thousand seed weight, straw yield and grain yield under different population density and levels of seed infections differed significantly. Significantly higher (45.60) and lower (40.50) 1000-grain weight was recorded under the treatments T_1 (0% seed infection) with a seed rate of 200 seeds/m^2 and under the treatment T_6 (45.1-60% seed infection) with a sowing rate of 400 seeds/m^2, respectively. Straw yield under different treatment combinations ranged from 3.17-4.21 t/ha where highest and lowest straw yield was obtained under the treatment combination of T_1 X 200 seeds/m_2 and T_6 X 400 seeds/m^2, respectively. Similar trends were found in grain yield where significantly higher grain yield (3.43 t/ha) was recorded when healthy seeds (0% infection) were sown @ 200 seeds/m^2. On the other hand lower grain yield (2.58 t/ha) was recorded when maximum levels of infected seeds (45.1-60.0% seed infection) were sown @ 400 seeds/m^2.

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