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Evaluation of BAU-Biofungicide and selected plant extractson yield and yield contributing characters of wheat cv. Kanchan

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Abstract
Efficacy of BAU-Biofungicide (a Trichoderma based preparation), aqueous extracts of Neem and Garlic clove and an inducer Bion were evaluated in the field as seed-treatment or seed-treatment along with foliar application to manage leaf blight disease of wheat caused by Biopolaris sorokiniana in cv. Kanchan from November, 2015 to April, 2018 in Dhynna Rampal Block, Tangail, Bangladesh. In addition, a chemical fungicide (Tilt) was used as positive control and an untreated negative control were included in the experiment.Three years of field trials, seed treatment with BAU-Biofungicide (3%) resulted significant effect in increasing seedlings emergence /10m^2 and reducing seedling mortality. Seed treatment with BAU-Biofungicide plus BAU-Biofungicide spray, yielded the highest plant height, number of effective tillers/m^2 and length of ear in comparable to Tilt and other treatments. According to final field experiment in the year 2017-18, BAU-Biofungicide, yielded the highest plant height and length of ear in comparable to Tilt and other treatments. BAU-Biofungicide showed excellent effect in producing the number of healthy grains/ear (37.6), where Tilt produced (39.7). The highest grain yield (3.44 t/ha) were obtained by applying Tilt followed by seed treatment with BAU-Biofungicide plus BAU-Biofungicide spray resulting 3.18 t/ha which were 37.26% higher grain yield over control. In final field experiment in the year 2017-18, the highest Benefit –Cost Ratio (BCR) was obtained in 2.80:1 when plots were sprayed with Tilt followed by seed treatment with BAU-Biofungicide plus BAU-Biofungicide spray in 2.58:1. BAU-Biofungicide may be successfully used by the farmers for obtaining higher yield and yield contributing characters viz., number of plants/m^2, number of effective tillers/m^2,length of ear, number of healthy grains/ear, grain weight and grain yield etc.

Key Words: *Leaf blight, BAU-Biofungicide, Wheat, Leaf extracts, Tilt*

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I. Introduction

Wheat is one of the important cereal crops that suffers from a huge number of diseases caused by fungi, bacteria, viruses, nematode and mycoplasma. Pathogens are the most responsible as well as limiting factors in cultivation of the crop in many parts of the world.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 (Panna *et al*., 2009). Among various factors that affect seed health, the most important are the seed borne fungi that lower seed germination and reduce seed vigor resulting in low yield.The severity of Bipolaris leaf blight disease has been increased in an alarming proportion in Bangladesh (Alam *et al*., 1995). In farmer's field, the average yield loss of wheat due to leaf blight disease was estimated upto 25% and it could reach to 100% in case of severe infection (Malaker *et al*., 2004). Hossain and Azad (1994) also found that *Bipolaris sorokiniana* at flag leaf stage showed 7-100% reduction in formation of grains/ear.

The causal organism of leaf blight of wheat is *Bipolaris sorokiniana* (Chowdhury *et al*., 2010). The teleomorphic state of this fungus is *Cochliobolus sativus*. The fungus of leaf blight disease is also the causal agent of other diseases like common root rot, foot rot, seedling blight, black point and seed rot of wheat. The disease severity is directly related to the humidity, temperature and soil nutrient condition. It is the economically most important foliar pathogen of wheat. While carrying and disseminating the pathogen, the seed itself may be victimized resulting the black pointed and shrivelled seeds (Rashid and Fakir, 2003). Black point caused by mainly *Bipolaris sorokiniana* is an important seed-borne disease of wheat in many wheat growing countries of the world including Bangladesh (Fakir, 1998; Zishan *et al.*, 2005; Hasabnis *et al.*, 2006).The disease occurs almost all over the world wherever wheat is grown (Mathur and Cunfer, 1993). Impaired seed germination and significant reduction in seedling vigour and grain yield to black point infection have been reported at home and abroad (Malaker and Mian, 2002). Black point infection becomes severe when prolonged wet weather prevails during grain filling period of the crop. In case of severe infection, the grain may be completely discolored and

shriveled. *Bipolaris sorokiniana* is reported to be highly seed transmitted causing seedling blight, Bipolaris leaf blight and black point in growing crop (Rashid *et al*., 1994). The black point has an adverse effect on seed weight, germination and grain yield. In Bangladesh, the prevalence of the disease was found to vary from 5 to 55% depending on different varieties grown in major wheat growing areas (Dey *et al.,* 1992). Black point disease of wheat causes significant yield loss, reduces the quality of the seed and has appeared as a potential threat for seed producer as well as to the farmers in Bangladesh. Increased seedling mortality and reduced seedling vigour and grain yield are also experienced when black pointed seeds are used for sowing (Rashid and Fakir 1998; Hossain 2000; Malaker and Mian, 2002). It is important that clean and healthy seeds are to be used as planting materials in order to increase germination and productivity. Contaminated seeds can often result in poor germination and poor seedling vigour and resulting unhealthy crops (Haque *et al*., 2007). Increase in awareness about environment, many farmers are interested in growing their crops with minimal orno synthetic chemical inputs. In several studies it has been found that extracts of garlic and neem increased seed germination and improved seedling development (Hasan *et al.,* 2005; Hossain *et al.,* 2016; Miah *et al.,* 2017).

Biopesticides are generally effective against soil-borne plant pathogens like species of *Pythium*, *Phytophthora*, *Rhizoctonia*, *Fusarium*, etc. Several stains of *Trichoderma* have been found to be effective as biocontrol agent of various soil borne fungi such as *Fusarium* sp., *Sclerotium* sp., *Rhizoctoniasolani* etc.So, *Trichoderma harzianum* may eco-friendly be used as a biocontrol agent and the nature will relatively be undisturbed and many beneficial micro-organisms in the soil will be saved. It may play an important role in reducing the seedling disease incidence and greater percentage plant stands in the field (Hasan and Alam, 2007). In several field experiments, it has been observed that the biocontrol agent has great influence on yield and yield attributes of crop plants. BAU-Biofungicide, a *Trichoderma* based preparation resulted significant higher germination and plant stand, less disease incidence and higher yield of different crops (Hossain, 2011; Hossain *et al.,* 2016). Hossain (2011) reported that BAU-Biofugicide was a unique technology for crop production in Bangladesh which was found environmental friendly.Treating of seeds with BAU-Biofungicide resulting strong barrier on the seed surface to protect the seed from seed borne pathogens as well as it protects the seed from soil borne pathogens when treated seeds are sown in the field or in the bed (Hossain, 2011). Over the past few decades, agricultural production has increased and farmers rely on chemical pesticides for protecting plants against pathogens.Hossain*et al.,*(2016) conducted an experiment with 13 plant extracts along with BAU-Biofungicide of wheat cv. Kanchan and reported that BAU-Biofungicide treated seeds was effective to increase seed germination, lowest disease severity and obtained grain yield. Sultana *et al.* (2009) evaluated BAU-Biofungicide in laboratory and field condition in comparison with chemical fungicide to control leaf spot of wheat in cv. Kanchan. Both in laboratory and field experiment, significantly highest germination, lowest post emergence death, remarkable reduction of leaf blight severity and highest grain yield were observed in BAU-Biofungicide treated seed as compared to chemical fungicide. When a physical, chemical or biological agent induces production/ accumulation of defense components in the host or activates defense mechanism, it may be regarded as induced or acquired resistance (Purkayastha, 1998). Resistance can be induced by naturally occurring metabolites or by chemical substances. The protection is based on the stimulation of defense mechanisms by metabolic changes enabling the plants to defend themselves more efficiently. From this point of view induced resistance is considered to be a procedure for biological plant protection in which the plant, not the pathogen, is the target. Raum (1997) reported Bion (Benzothiadiazole) as a plant activator that can improve the natural resistance of plants to diseases.

Chemical control method is mostly preferred by the growers of the world including Bangladeshi farmers in controlling Bipolaris leaf spot disease. But the regular use of chemical fungicides can potentially pose a risk to the environment, particularly if residues persist in the soil or migrate off-site and enter waterways (Kibria *et al.,* 2010). To ensure the sustainability of production systems, a balance needs to be found between controlling fungal disease risks to crops and protecting terrestrial and aquatic ecosystems (Wightwick, 2010). Biological control represents a natural and ecological approach for controlling diseases reduce the usage of chemical inputs and their effects on environment. It is more stable and longer lasting than the controls and is comparative with the concepts and goals of integrated pest management and sustainable agriculture. Concern about the health, safety and environment effects of agriculture chemicals in water, soil and food, the use of biological control need to be emphasized strongly. Keeping in consideration present work has been undertaken to evaluate efficiency of selected plant extracts viz. *Azadirachta indica* and *Allium sativum*; BAU Biofungicide; Bion and chemical fungicide Tilt 250EC to control Bipolaris leaf blight of wheat.

II. Materials and Methods

The experiments were conducted during the period from November, 2015 to April, 2018 in the farmer field of village Dhanna Rampal Block, Tangail Sadar, Tangail, Bangladesh. Seed samples of wheat (*Triticum aestivum* L.) var. Kanchan and Prodip were collected from Wheat and Maize Research Institute, Noshipur,

Dinajpur. The experiment was laid out in RCBD having three replications for each treatment, where block to block, plot to plot and line to line distances were 1.5 m, 1m and 20 cm, respectively.

Preparation of fungicidal solutions, plant extracts and BAU Bio-fungicide

Ten different treatments were selected for the field experiment. The treatments were as follows:

$\mathbf{T_1}$ = Seed treatment with Neem extract (1%), $\mathbf{T_2}$ = Seed treatment with Neem extract (1%) + Neem extract spray (1%), $\mathbf{T_3}$ = Seed treatment with Garlic extract (1%), $\mathbf{T_4}$ = Seed treatment with Garlic extract (1%) +Garlic extract spray (1%), $\mathbf{T_5}$ = Seed treatment with BAU-Biofungicide (3%), $\mathbf{T_6}$= Seed treatment with BAU-Biofungicide (3%) +BAU-Biofungicide spray (3%), $\mathbf{T_7}$ = Seed treatment with Bion@ 50 ppm, $\mathbf{T_8}$ = Bion as spray @ 50 ppm, $\mathbf{T_9}$ = Tilt as spray @ 0.1%, $\mathbf{T_{10}}$ = Untreated control. Out of 10 different treatments, 5 treatments were selected for final field experiment in 3rd cropping season during the period of 2017-18.

Five treatments were as follows: $\mathbf{T_2}$ = Seed treatment with Neem extract (1%) + Neem extract spray (1%), $\mathbf{T_6}$= Seed treatment with BAU-Biofungicide (3%), $\mathbf{T_7}$ = Seed treatment with BAU-Biofungicide (3%) +BAU-Biofungicide spray (3%), $\mathbf{T_9}$ = Tilt as spray @ 0.1%, $\mathbf{T_{10}}$= Untreated control.

The plant extracts were prepared by crushing the plant parts in a blender with distilled water in 1:1 ratio (e.g. 1:1= 100 g plant material crushed in 100 ml water) following the method of Hossain *et al.* (1997) and BAU-Biofungicide (30 g) was prepared in a 1000 ml beaker containing tube well water and stirred. The filtrate was made to volume as 1L by adding tube well water and used as 3% BAU-Biofungicide (Hossain 2011).

Seed treatment

Required amount of seeds presented each treatment with plant extracts (at 1% suspension), BAU Biofungicide (at 3% seed weight) and Tilt (at 0.1%) separately over night by dipping method and then separate the seeds by air dried 1% suspension of plant extracts. Plant extracts and BAU-Biofungicide were prepared according to the method of Hossain and Azad (1994) and Hossain (2011).

Collection of data on seedling emergence and seedling mortality

Data on seedling emergence was recorded at 15 days after sowing. It was continued four times at every 7 days interval.

Application of foliar spray

Selected plant extracts (Garlic and Neem), BAU-Biofungicide, Bion and Tilt were applied for controlling Bipolaris leaf spot of wheat cv. Kanchan. Bion (50 ppm) spray solution was sprayed in the plots as per treatment at seedling stage for one time. The spray schedule was started just after appearance of leaf spot symptom and three sprays were maintained at 15 days interval.

Recording of data

Ten plants of each plot were randomly selected and tagged for data collection. The data were collected on the following parameters:

i. Number of seedling /10m^2
ii. Plant height (cm)
iii. Number of effective tillers/m^2
iv. Length of ear (cm)
v. Number of grains/ear
vi. Number of healthy and diseased grains/ear
vii. Weight of grains/ear (g)
viii. Weight of healthy and diseased grains/ear
ix. 1000-grain weight (g)
x. Grain yield/ m^2 (g)
xi. Grain yield (kg/ha)

The Benefit –Cost analysis was done following the method of Reddy and Reddy (1992). Benefit-Cost Ratio was calculated following the formula as given bellow:

$$\boldsymbol{BCR} = \frac{\mathbf{A} \times \mathbf{C}}{\mathbf{B}}$$

A = Yield (kg/ha)
B = Cost of cultivation of the crop (Tk. /ha)
C = Price of the product (Tk. /Kg)

The collected data were analyzed by using Duncan's Multiple Range Test (DMRT) following Web Agro Stat Package computer program following the procedure as described by Gomez and Gomez (1984).

III. Results and Discussion

Experiments were conducted to determine the efficacy of different treatments including foliar spray in controlling leaf blight disease of wheat cultivars Kanchan under field condition. Number of plants/10 m^2, field emergence, seedling mortality and plant stand varied significantly among the treatments. Effect of plant extracts and seed treatment of BAU-Biofungicide showed significant effect in increasing the field performance especially seedling emergence, reducing seedling mortality, plant stand, plant height and number of effective tillersin cultivar Kanchan planted in the field in 2015-16, 2016-17 and 2017-18. At all the four different DAS, maximum number of plants was recorded in plots where BAU-Biofungicide treated seeds were sown and minimum number of plants was recorded in control plots during the year 2015-16, 2016-17 and 2017-18 (Table 1). Highest plant height and maximum length of ear were recorded in seed treatment with BAU-Biofungicide sprayed plot and lowest plant height & minimum length of ear were recorded in control treatment during the year 2015-16, 2016-17 and 2017-18 (Table 2). Hasan *et al.* (2012) evaluated the antagonistic effect of *Trichoderma harzianum* of seed-borne fungal pathogens of wheat and reported *Trichoderma harzianum* was most effective in increasing field emergence (plant stand). Hossain *at al.* (2016) reported that BAU-Biofungicide was found to be effective in increasing the highest number of plants/m^2 and effective tillers/m^2. Sultana *et al*. (2009) stated that significantly lowest post emergence death was recorded in Bavistin treated seed (5.97%) preceded by BAU-Biofungicide treated seed (8.62%) that resulted 67.35% and 52.87%, respectively decrease over control. Hossain (2011) stated that BAU-Biofungicide treated seeds increased the seed germination, plant stand and seedling vigour. Hasan *et al.* (2005) reported that seed treatment of wheat with alcoholic extract of *Azadirachta indica* increased seed germination by 15.4% and that of garlic extract increased field emergence by 37.93% over control and plant stand was increased. Adekunle *et al*. (2001) repoted that seeds treated with *Trichoderma spp.* formulations resulted in significantly greater percentage of plant stands than the control.BAU-Biofungicide used as seed treatment plus spray produced the height plant height and maximum number of effective tillers.Najnine *et al*. (2016) stated that the highest plant height (112.69 cm) and ear length (11.86) were recorded in seed treatment with foliar spray of BAU-Biofungicide and the lowest in untreated control. Kakraliya *et al*. (2018) evaluated the effect of bio-agents, botanical and fungicides against *Alternaria* leaf blight of wheat who reported maximum plant height was observed in *Trichoderma viride* (78.82 cm) followed by *Trichoderma harzianum* (78.27 cm) as compared to control (70.04 cm).

Among the treatments, the highest grain yield and 1000-grain weight was achieved with foliar spray of Tilt followed by seed treatment with BAU-Biofungicide plus BAU-Biofungicide spray and the lowest grain yield was observed in untreated control during the years 2015-16, 2016-17 and 2017-18, respectively (Table-3).Seed treatment with BAU-Biofungicide plus BAU-Biofungicide spray gave better performance to produce grain yield as well as 1000- grain weight as compared to untreated control in present study. The findings of the present study have been supported by Najnine *et al.(*2016) who stated that seed treatment plus foliar spray of BAU-Biofungicide resulted 35.64% increase of yield over untreated control and the 1000-grain weight (41.59 g). Similar observation were also found by Hossain *et al.* (2016) who evaluated the efficacy of BAU-Biofungicide in controlling leaf blight of wheat cv. Kanchan and reported that seed treatment of BAU-Biofungicide resulted 29.87% higher grain yield over control. Sultana *et al*. (2009) evaluated BAU-Biofungicide to control leaf blight of wheat under field condition and stated that seed treatment plus foliar spray of BAU-Biofungicide resulted 33.36% higher grain yield over control. In several field experiments, it had been observed that *Trichoderma harzianum* has great influence on yield and yield attributes of winter wheat crops that has increased by 160% and the 1000-grain weight by 4% (Knudsen *et al*., 1995). Thus, BAU-Biofungicide is not only a superior biofungicide, but also a good bioagent to increase yield and yield contributing characters of wheat.

Comparative effect of seed treatments and foliar spray on number and weight of healthy and diseased grains/ear of wheat cv. Kanchan were studied. Maximum number of healthy grains/ear were recorded in foliar spray of Tilt followed by BAU-Biofungicide seed treatment plus sprayin the year 2015-16, 2016-17 and 2017-18, respectively (Table 4 and Table 5). The findings of the present study have been strongly supported by Hossain*et al.* (2016) who observed that seed treatment plus foliar spray of BAU-Biofungicide showed excellent performance in producing higher number (31.73) of healthy grains/ear and weight of total grains/ear (1.662 g). Similar work had been done by Muthomi *et al*. (2007). Muthomi *et al.* (2007) reported that *Trichoderma* spp. had been found effective in reducing disease severity and increased the number of healthy grains/ear of wheat. In BCR analysis, according to final field experiment in the year 2017-18, maximum net profit was achieved in foliar spray of Tilt (0.1%) by Tk. 77441.00/- but net profit by seed treatment plus foliar spray of BAU-Biofungicide (3%) was Tk. 68100.00/-. The Benefit –Cost Ratio (BCR) was 2.58:1 in foliar spray of BAU-Biofungicide, while by 2.80:1 in foliar spray of Tilt (Table 6). Hossain *et al.* (2016) applied seed treatment plus foliar spray of BAU-Biofungicide and Tilt for controlling of leaf blight of wheat under field condition. The Benefit –Cost Ratio (BCR) was achieved 2.16 in BAU-Biofungicide while by (Bavistin + Tilt) was 2.33:1.

Table 1. Effect of different treatments on the number of plants/ 10m^{2}of wheat cv. Kanchan duringthe period of 2015-16, 2016-17 and 2017-18

Treatment	Number of plants/10 m^2											
	Year 2015-16				Year 2016-17				Year 2017-18			
	15 DAS	22 DAS	29 DAS	36 DAS	15 DAS	22 DAS	29 DAS	36 DAS	15 DAS	22 DAS	29 DAS	36 DAS
T_1	1154.0 cd	1095.0 c	997.3 c	915.0 cd	1621.0bc	1513.6bc	1413.0c	1326 bcd				
T_2	1174.0 c	1081.6 c	1015.6 c	934.0 c	1606.0bc	1492.0bc	1378.3cd	1306.3cd	1557.0b	1498.6b	1421.6c	1357.3b
T_3	1241.6 b	1216.0 b	1088.3 b	1012.0 b	1641.3bc	1563.6bc	1429.3c	1365.0bc				
T_4	1239.6 b	1172.0 b	1081.6 b	1008.3 b	1674.3b	1584.3b	1510.0b	1394.0b				
T_5	1383.0 a	1335.3 a	1282.0 a	1194.6 a	1853.3a	1786.0a	1723.67a	1608.3a	1580.6ab	1523.0ab	1468.6b	1418.0a
T_6	1360.0 a	1335.0 a	1268.0 a	1163.0 a	1800.0a	1756.0a	1695.0a	1572.0a	1622.6a	1570.6a	1524.3a	1462.6a
T_7	1108.0 d	1051.6 cd	961.6 cd	879.0 d	1502.0e	1492.0bc	1330.6de	1226.0e				
T_8	1134.0 cd	1090.0 c	968.6 cd	894.0 cd	1582.0cd	1493.3bc	1411.6c	1284.6de				
T_9	1124.0 cd	1053.3 cd	962.6 cd	886.0 cd	1588.0cd	1477.3cd	1381.3cd	1290.3cde	1476.6c	1407.3c	1321.0d	1255.0c
T_{10}	1105.0 d	1022.3 d	934.3 d	867.0 d	1515.3de	1385.6d	1285.3e	1217.0e	1472.3c	1400.6c	1324.0d	1245.6c
CV (%)	2.81	2.84	3.09	2.94	2.80	3.72	2.69	3.41	2.11	1.81	1.48	2.06

In a column, figures having same letter(s) do not differ significantly at 1% level of significance by DMRT.Data represent means of three replications, DAS = Days After Sowing, T_1 = Seed treatment with Neem extract (1%), T_2 = Seed treatment with Neem extract (1%) + Neem extract spray (1%), T_3 = Seed treatment with Garlic extract (1%), T_4 = Seed treatment with Garlic extract (1%) + Garlic extract spray (1%), T_5 = Seed treatment with BAU-Biofungicide (3%), T_6 = Seed treatment with BAU-Biofungicide (3%) + BAU-Biofungicide spray (3%), T_7 = Seed treatment with Bion@ 50 ppm, T_8 = Bion as spray @ 50 ppm, T_9 = Tilt as spray @ 0.1%, T_{10} = Untreated control

Table 2. Effect of different treatments on plant height, number of effective tillers and length of ear at maturity stage of wheat cv. Kanchan during the period of 2015-16, 2016-17 and 2017-18

Treatments	Year 2015-16			Year 2016-17			Year 2017-18		
	Plant height (cm)	Number of effective tillers/m^2	Length of ear (cm)	Plant height (cm)	Number of effective tillers/m^2	Length of ear (cm)	Plant height (cm)	Number of effective tillers/m^2	Length of ear (cm)
T_1	109.43 c	221.6 cd	14.76 c	109.23 c	228.67 de	15.17 cd			
T_2	110.30 c	227.6 bc	15.36 bc	109.93 bc	242.33 bc	15.60 bc	112.27 b	237.33 b	17.33 ab
T_3	110.83 bc	226.6 bc	15.46 bc	109.33 c	231.00 cd	15.33 cd			
T_4	110.43 c	240.0 ab	15.53 b	111.53 ab	242.67 bc	15.63 bc			
T_5	113.57 ab	241.3 ab	15.90 ab	112.00 a	244.67 b	15.93 ab	113.63 a	240.33 b	17.60 a
T_6	113.83 a	248.6 a	16.43 a	113.13 a	254.67 ab	16.23 a	114.17 a	264.00 a	17.70 a
T_7	105.50 d	208.0 de	13.53 d	108.67 cd	216.33 e	15.27 cd			
T_8	109.23 c	221.3 cd	13.40 d	109.37 c	226.67 de	15.03 d			
T_9	110.70 bc	250.6 a	15.23 bc	109.93 bc	258.67 a	15.83 ab	110.30 c	263.33 a	16.97 bc
T_{10}	105.57 d	196.6 e	13.26 d	107.20 d	201.67 f	14.30 e	110.10 c	207.66 c	16.73 c
CV (%)	1.50	4.52	2.95	1.00	3.32	1.76	0.61	5.02	1.14

In a column, figures having same letter(s) do not differ significantly at 1% level of significance by DMRT. Data represent the means of three replications, T_1 = Seed treatment with Neem extract (1%), T_2 = Seed treatment with Neem extract (1%) + Neem extract spray (1%), T_3 = Seed treatment with Garlic extract (1%), T_4 = Seed treatment with Garlic extract (1%) + Garlic extract spray (1%), T_5 = Seed treatment with BAU-Biofungicide (3%), T_6 = Seed treatment with BAU-Biofungicide (3%) + BAU-Biofungicide spray (3%), T_7 = Seed treatment with Bion@ 50 ppm, T_8 = Bion as spray @ 50 ppm, T_9 = Tilt as spray @ 0.1%, T_{10} = Untreated control

Table 3. Effect of different treatments on yield and yield contributing characters of wheat cv. Kanchan during the period of 2015-16, 2016-17 and2017-18

Treatments	Year 2015-16			Year 2016-17			Year 2017-18		
	1000-grain weight (g)	Grain weight/m^2 (g)	Grain yield (Kg/ha)	1000-grain weight (g)	Grain weight/m^2 (g)	Grain yield (Kg/ha)	1000-grain weight (g)	Grain weight/m^2 (g)	Grain yield (Kg/ha)
T_1	26.96 de	202.5 de	2025.3 de (11.65)	29.61 cd	247.209 e	2472.0 e(12.10)			
T_2	28.81 c	219.7 cd	2197.6 cd (21.15)	31.09 c	266.10 cd	2661.0 cd(20.68)	35.20 c	271.60 bc	2716.0 bc (17.42)
T_3	28.34 cd	203.7 de	2037.0 de (12.29)	30.18 cd	247.80 de	2478.0 de(12.38)			
T_4	29.07 c	224.1 c	2241.0 c (23.54)	31.10 c	266.50 cd	2665.0 cd(20.86)			
T_5	29.15 bc	224.3 c	2243.3 c (23.67)	31.53 bc	267.60 c	2676.0 c(21.36)	36.07 bc	274.00 b	2740.0 b (18.46)
T_6	30.90 b	254.8 b	2548.6 b (40.50)	33.85 b	311.60 b	3116.0 b(41.31)	38.67 ab	317.500 a	3175.0 a (37.26)
T_7	25.30 ef	188.0 ef	1880.6 ef (3.67)	28.54 d	241.40 e	2414.0 e(9.47)			
T_8	27.81 cd	201.9 e	2019.0 e (11.30)	29.64 cd	246.70 e	2467.0 e(11.88)			
T_9	34.84 a	310.3 a	3103.0 a (71.06)	39.49 a	342.50 a	3425.0 a(55.32)	40.63 a	344.00 a	3440.0 a (48.72)
T_{10}	24.33 f	181.4 f	1814.0 f	26.01 e	220.50 f	2205.0 f	30.73 d	231.30 c	2313.0 c
CV (%)	3.67	4.68	4.68	4.68	4.14	4.14	3.91	7.74	7.74

In a column, figures having same letter(s) do not differ significantly at 1% level of significance by DMRT. Data represent the means of three replications, T_1 = Seed treatment with Neem extract (1%), T_2 = Seed treatment with Neem extract (1%) + Neem extract spray (1%), T_3 = Seed treatment with Garlic extract (1%), T_4 = Seed treatment with Garlic extract (1%) + Garlic extract spray (1%), T_5 = Seed treatment with BAU-Biofungicide (3%), T_6 = Seed treatment with BAU-Biofungicide (3%) + BAU-Biofungicide spray (3%), T_7 = Seed treatment with Bion@ 50 ppm, T_8 = Bion as spray @ 50 ppm, T_9 = Tilt as spray @ 0.1%, T_{10} = Untreated control

Table 4. Effect of different treatments on number and weight of healthy and diseased grains/ear of wheat cv. Kanchan during period of 2015-16 and 2016-17

Treatment	Year 2015-16						Year 2016-17					
	Healthy grains/ ear	Diseased grains/ ear	Total grain/ear	Healthy grains/ ear(g)	Diseased grains/ ear (g)	Total grains/ear (g)	Healthy grains/ ear	Diseased grains/ ear	Total grain/ ear	Healthy grains/ ear(g)	Diseased grains/ ear(g)	Total grains/ ear(g)
T_1	26.3 c	10.7 b	37.4	0.876 e	0.366 c	1.242cde	30.07 b	9.43 c	39.50	0.936 de	0.466 bc	1.402 cde
T_2	28.1 bc	9.9 bc	38.0	0.976 cde	0.308 d	1.284 cd	32.30 b	8.10 e	40.40	1.156 bc	0.416 c	1.572 bc
T_3	28.4 bc	10.bc	38.4	0.903 de	0.373 c	1.276 cd	30.90 b	9.36 cd	40.26	1.053 cd	0.476 bc	1.529 bcd
T_4	29.1 bc	9.2 bc	38.3	1.003 cd	0.297 de	1.300 c	32.43 b	8.23 de	40.66	1.156 bc	0.413 c	1.569 bc
T_5	30.5 ab	8.5 c	39.0	1.023 c	0.293 de	1.316 bc	33.03 b	8.26 de	41.29	1.192 bc	0.386 cd	1.578 b
T_6	33.6 a	5.5 d	39.1	1.154 b	0.253 ef	1.407 b	36.53 a	5.96 f	42.49	1.313 b	0.366 cd	1.679 b
T_7	22.4 d	13.7 a	36.1	0.733 fg	0.461 b	1.194 de	26.73 c	11.06 b	37.79	0.836 e	0.526 b	1.362 de
T_8	27.2 c	10.3 bc	37.4	0.753 f	0.430 b	1.183 de	30.03 b	9.70 c	39.73	0.904 de	0.456 bc	1.360 e
T_9	33.4 a	4.9 d	38.3	1.344 a	0.241 f	1.585 a	37.70 a	4.63 g	42.33	1.809 a	0.303 d	2.112 a
T_{10}	21.2 d	14.9 a	36.1	0.643 g	0.531 a	1.174 e	24.70 c	12.77 a	37.47	0.657 f	0.686 a	1.343 e
Level of sig.	**	**	NS	**	**	**	**	**	NS	**	**	**
CV (%)	6.65	11.62	7.09	6.47	9.69	4.91	5.78	7.65	4.81	9.24	13.36	6.76

In a column, figures having same letter(s) do not differ significantly at 1% level of significance by DMRT. Data represent the means of three replications, T_1 = Seed treatment with Neem extract (1%), T_2 = Seed treatment with Neem extract (1%) + Neem extract spray (1%), T_3 = Seed treatment with Garlic extract (1%), T_4 = Seed treatment with Garlic extract (1%) + Garlic extract spray (1%), T_5 = Seed treatment with BAU-Biofungicide (3%), T_6 = Seed treatment with BAU-Biofungicide (3%) + BAU-Biofungicide spray (3%), T_7 = Seed treatment with Bion@ 50 ppm, T_8 = Bion as spray @ 50 ppm, T_9 = Tilt as spray @ 0.1%, T_{10} = Untreated control

Table 5. Effect of different treatments on number and weight of healthy and diseased grains/ear of wheat cv. Kanchan during period of 2017-18

Treatments	Number of			Weight of		
	Healthy grains/ ear	Diseased grains/ ear	Total grain/ ear	Healthy grains/ ear(g)	Diseased grains/ ear(g)	Total grains/ ear (g)
T_1	34.2 b	9.2 b	43.4	1.164 d	0.413 b	1.577 c
T_2	35.3 b	8.2 b	43.5	1.264 c	0.343 bc	1.607 c
T_3	37.6 ab	6.0 c	43.6	1.411 b	0.323 cd	1.734 b
T_4	39.7 a	3.8 d	43.5	1.966 a	0.258 d	2.224 a
T_5	28.0 c	12.1 a	40.1	0.851 e	0.523 a	1.374 d
Level of significance	**	**	NS	**	**	**
CV (%)	6.58	10.58	4.47	2.67	12.69	3.58

In a column, figures having same letter(s) do not differ significantly at 1% level of significance by DMR,
Data represent the means of three replications
T_1= Seed treatment with Neem extract (1%) + Neem extract spray (1%), T_2 = Seed treatment with BAU-Biofungicide (3%), T_3 = Seed treatment with BAU-Biofungicide (3%) + BAU-Biofungicide spray (3%), T_4 = Tilt as spray @ 0.1%, T_5 = Untreated control

Table 6. Benefit- Cost Ratio (BCR) analysis of seed treatment & foliar spray with selected plant extracts; BAU- Biofungicide and Tilt in controlling leaf blight of wheat cv. Kanchan in 2017-18 in the field.

Sl.No.	Functions	Neem seed treatment (1%) + Neem extract spray (1%)	Seed treatment with BAU-Biofungicide (3%)	Seed treatment with BAU-Biofungicide (3%) + BAU-Biofungicide spray (3%)	Tilt as spray(0.1%)	Control
1	Seed (Tk.)	5520	5520	5520	5520	5520
2	Preparation of land (Tk.)	6669	6669	6669	6669	6669
3	Seed sowing (Tk.)	600	600	600	600	600
4	Fertilizer cost (Tk.)	10620	10620	10620	10620	10620
5	Weeding and irrigation (Tk.)	6000	6000	6000	6000	6000
6	Cost of treatments (Tk.)	1248	216	5616	5550	-------
7	Insecticide cost	500	500	500	500	500
8	Harvest cost (Tk.)	4500	4500	4500	4500	4500
9	Cost of processing (Tk.)	1500	1500	1500	1500	1500
10	Transportation cost (Tk.)	500	500	500	500	500
11	Others cost (Tk.)	1000	1000	1000	1000	1000
12	Total cost of cultivation (TK.)	38657	37625	43025	42959	37409
13	Yield (Kg/ha)	2716.0	2740.0	3175.0	3440.0	2313.0
14	Sell price (Tk./ha)	95060.0	95900.0	111125.0	120400.0	80955.0
15	Profit (Tk./ha)	56403.0	58275.0	68100.0	77441.0	43546.0
16	(%) return over control	29.53	33.82	56.38	77.83	----------
17	Benefit-cost ratio	2.45:1	2.54:1	2.58:1	2.80:1	2.16:1

Legends: Labour cost: Tk.300/labour; Seed cost: Tk.46/Kg; Cost of ploughing: Tk.2223/ha (one time); Cost of Tilt: Tk.1850/liter, Cost of BAU- Biofungicide: Tk.60/Kg; Cost of neem leaf: Tk. 40/Kg; Fertilizer cost: Urea: Tk.16/Kg, TSP: Tk.24/Kg, MP: Tk.16/kg, Zypsum: Tk.10/Kg, Boric acid: Tk. 150/Kg and wheat sell price: Tk.35/Kg.

IV. Conclusion

BAU-Biofungicide showed better performance compare to chemical fungicide Tilt in controlling Bipolaris leaf blight disease of wheat. Based on the findings of the present study, it may be concluded that BAU-Biofungicide resulted highest reduction of Bipolaris leaf blight of wheat, increased grain yield significantly and reduced cost of production. Thus, BAU-Biofungicide may be successfully used by the farmers for eco-friendly management of wheat disease for obtaining higher yield by reducing black pointed seeds.

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