Biological Control of Leaf Spot of Groundnut

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Abstract

The leaf spot or Tikka disease (*Cercospora arachidicola* and *Cercosporidium personatum*) of groundnut (*Arachis hypogaea* L.) is the predominant, devastating, common constraints and economically important foliar fungal disease and major yield reducing factor of groundnut, not only in Bangladesh, but also all over the world. The yield loss was calculated in the groundnut due to early and late leaf spot (Tikka) by over 30-48% in Bangladesh. The efficacy of three botanicals viz. neem leaf (*Azadirachta indica*), debdaru leaf (*Polyalthia longifolia*), and datura leaf (*Datura metel*), BAU-Biofungicide along with a check (Bavistin) and untreated control were evaluated as foliar spray in the field in the present research work. Among the treatments, BAU-Biofungicide, extracts of neem leaf, datura leaf and debdaru leaf showed excellent performance in controlling leaf spot and increasing pod yield by 53.61, 51.91, 40.85 and 38.72%, respectively as compared to control. In case of seedling germination, BAU-Biofungicide as seed treatment+ spray gave 97.77% germination followed by extracts of neem leaf (88.14%), datura leaf (93.33%) and debdaru leaf (95.55%). BAU-Biofungicide as seed treatment+ spray produced higher length and weight of shoot and root and vigour index as compared to untreated control. Maximum vigour index was observed under BAU-Biofungicide spray. BAU-Biofungicide as seed treatment+ spray gave higher plant height, number of leaves and minimum number of infected leaves as compared to control. Minimum percentages of leaf area diseased were obtained with BAU-Biofungicide as seed treatment + spray followed by Bavistin. BAU-Biofungicide, extracts of neem leaf, datura leaf and debdaru leaf showed promising performance in number and weight of pods and pod yield. Maximum weight of pods/plant and weight of mature pods/plant was achieved with BAU-Biofungicide as seed treatment + sprays followed by extract of neem leaf spray. The highest net profit was recorded with the use of BAU–Biofungicide as seed treatment + foliar spray by Tk. 176768.00/ha followed by extracts of neem leaf Tk. 172275.00/ha, while the lowest Tk. 96443.00/ha in untreated control. Maximum Benefit-Cost Ratio (BCR) 1: 2.77 was found in BAU–Biofungicide seed treatment + spray followed by BAU–Biofungicide seed treatment (1: 2.65), BAU–Biofungicide spray (1: 2.64) and extracts of neem leaf (1:2.62).

Keywords: Groundnut, Leaf Spot, BAU-Biofungicide, Biological control, Benefit-Cost Ratio

Introduction

Groundnut (*Arachis hypogaea* L.), also known as peanut is an important annual legume crop belonging to the family Fabaceae growing in many tropical and subtropical countries of the world (Wudiri and Fatoba, 1992). It is a multipurpose and highly nutritious crop containing oil, food and its

foliage or haulm provides a valuable fodder for livestock. It contains about 48.32% oil, 22-25% protein, 20% carbohydrate, 5% fiber and ash, vitamin B and E as against 30 to 35% in other oil crops grown in Bangladesh (Khaleque, 1986). The total groundnut (Rabi) production in 2009-10 in Bangladesh was about 43060 metric tons from 66375 acres of land and average yield 1603.03 kg/ha (BBS, 2010). The national average yield of groundnut in Bangladesh is very low i.e. only 1603.03 kg/ha (BBS, 2010) compared to those of 2200 kg/ha in South America (Krishnan and Ramachandran, 1991), and 6000-7000 kg/ha in China (Yanhao *et al*., 1996). Among the various factors responsible for low yield, disease play an important role for limiting the production of groundnut in Bangladesh, where leaf spot is the most devastating one and has a large negative impact on yield and quality of groundnut. Among the diseases, early leaf spot (caused by *Cercospora arachidicola S.* Hori) and late leaf spot (caused by *Cercosporidium personatum*) are most devastating and economically important foliar fungal disease and major yield reducing factor of groundnut worldwide (Khaleque, 1985 and Mirza, 1988). The early and late leaf spots of groundnut although caused by two fungal species, *C. arachidicola* and *C. personatum*, they are commonly referred together as Tikka disease. Early and late leaf spot occur either alone or together in the same field. Leaf spot symptoms appear at 30-36 days after sowing and increase in intensity up to harvest time. The detrimental effects of leaf spot are threefold; the yield of pod is reduced, the quality of the groundnut hay is lowered, and the fallen leaves provide organic matter on which inoculums of other fungi are produced. Loss in pod yield due to the diseases was recorded as 70% in groundnut (Subrahmanyam *et al*., 1980). The yield loss was calculated in the groundnut variety Dhaka-1 due to early and late leaf spot (Tikka) by over 30-48% in Bangladesh (Hossain and Naznin, 2005). Different plant extracts have been found to inhibit the conidial germination of *C. arachidicola* and *C. personatum* (Alam *et al*., 2002). Foliar spray with Bavistin @ 0.1% (Chandra and Verma, 1990) and Carbendazim @ 0.1% +Mancozeb @ 0.25% (Srinivas *et al*., 2002) has been practices in controlling the disease under field conditions. Now a day's research all over the world is much interested to control disease by biological means as well as alternate means. The use of plant extracts with antifungal activity offers an economical, safe and easily available alternative method for the management of leaf spot disease of groundnut (Rahman and Hossain, 1996). *Trichoderma* based preparation BAU-Biofungicides has been found to be effective in controlling seed, soil and air-borne disease of crops. Hossain (2011) reported successful control of tikka disease of groundnut by applying alternative means of plant disease control rather than by chemicals. In view of the above information, it is clear that research work on leaf spot disease caused by *C. arachidicola* and *C. personatum* is essential for control by plant extracts and biological control means instead of using chemicals to avoid environmental pollution. The present research work was undertaken to evaluate comparative efficacies of different botanicals viz. Datura leaf, Neem leaf, Debdaru leaf with BAU-Biofungicide and Bavistin for controlling leaf spot disease of groundnut, and to determine the Benefit–Cost Ratio (BCR) of the botanicals, BAU-Biofungicide and Bavistin application to control leaf spot of groundnut.

Materials and Method

The experiments were carried out at Field Laboratory, Department of Plant Pathology, Bangladesh Agricultural University (BAU), Mymensingh, during November, 2011 to June, 2012. The experiment was done by using Randomized Complete Block Design (RCBD) having three replications. The individual size of the plot was 1.5 m x 1.0 m. The spaces between Blocks and between plots were 1.0 and 1.0 m, respectively. The groundnut variety, Dhaka –1 which is popular and highly susceptible to leaf spot was used in this experiment. The seeds were sown in the field on December 10, 2011. The seeds were sown in line about 2-3 cm depth. Seed to seed and line to line distances were 10cm and 40 cm, respectively. The experiment was conducted to evaluate the efficacy of Bavistin (0.1%), BAU-Biofungicide (3%), Neem leaf extract (25%), Debdaru leaf extract (20%) and Datura leaf extract (20%). Suspension of all materials was used as foliar spray. Additional seed treatment was maintained with BAU-Biofungicide @ 3% of seed weight. So, there were eight treatments including a control. The experimental plot was inspected regularly to observe crop conditions and to record data on

different aspects. Five sprays each of Bavistin, botanicals and BAU-Biofungicide were given at 15 days interval with the help of a self-compressed hand sprayer to cover the plant canopy starting from 65 days after sowing.

Procedure of Vigour Test: Randomly selected 9 seedlings were uprooted carefully from each tray and washed thoroughly with running tap water. Data were recorded at 30 days after sowing (DAS). The Vigour Index (VI) was computed using the formula of Baki and Anderson (1973) as follow:

Vigor Index = (Mean shoot length + mean root length) × (Germination percent)

Assessment of leaf spot: Six plants from each unit plot were randomly selected for counting the number of healthy and diseased leaves, severity of disease intensity. Disease severity of those randomly selected leaves of each plot was assessed by counting percent leaf area infected. The plants were evaluated five times at 68, 83, 98, 113 and 128 days after sowing.
The following data were recorded up to growing period:

a) Germination (%)
b) Root length/plant
c) Shoot length/plant
d) Root weight/plant
e) Shoot weight/plant
f) Plant height (cm)
g) No. of leaf/plant
h) No. of infected leaf/plant
i) Total leaf area diseased/plant (%)

Plants were harvested after 166 days after sowing on May 27, 2012 and data were recorded after harvest on the following parameters:

a) No. of pods/plant
b) No. of mature pods/plant
c) No. of immature pods/plant
d) Weight of pods/plant (g)
e) Wt. of mature pods/plant (g)
f) Wt. of immature pods/plant (g)
g) Groundnut pods yield (Kg/ha)

Benefit – cost analysis (BCR): The Benefit-Cost analysis was done following the method of Mondal *et al.* (1994).

$$BCR = \frac{(A \times C) - B}{B}$$

Where,

A = Selling price (Tk./kg)
B= Cost of cultivation of the crops (Tk./ha)
C= Yield (Kg/ha)

The recorded data on different parameters were subjected to statistical analysis using MSTAT-C computer program to find out the significance of variation resulting from experimental treatments. The difference between the treatments means were evaluated for significance using Duncan's Multiple Range Test (DMRT) following the procedure as described by Gomez and Gomez (1984).

Results and Discussion

The Effect of three different selected botanicals, Bavistin and BAU-Biofungicide on germination (%), average root length/plant, average shoot length/plant, Vigor Index, average root weight/plant, average shoots weight/plant of groundnut cv. Dhaka-1 were determined (Table 1). The germination percentage of groundnut seeds cv. Dhaka-1 varied from 88.14 to 97.77%, where significantly the lowest percentage of germination was recorded with extract of neem leaf followed by control and the highest percentage of germination was found in BAU-Biofungicide as seed treatment+ spray. Naznin and Hossain (2005) observed 50.80% higher germination over the control in cowpea by applying BAU-Biofungicide. Hossain *et al.,* (2009) determined the effectiveness of BAU-Biofungicide as integrated management tool of seedling diseases of Blackgram. *Trichoderma harzianum* treated seed of blackgram resulted up to 16.66% seed germination over control (Hossain and Shamsuzzaman, 2003).

The highest root length/plant was recorded with extract of neem leaf (6.46 cm) followed BAU-Biofungicide as seed treatment (6.18 cm) and BAU-Biofungicide sprays (6.20 cm) and lowest was recorded extract of debdaru leaf (5.16 cm) followed by untreated control (5.38 cm). Significantly minimum vigour index was produced by extract of debdaru leaf (1362.35) and maximum vigour index was recorded in BAU-Biofungicide spray treatment (1583.88) at 30 DAS. Significantly the lowest root weight/plant was recorded in extract of datura leaf, debdaru leaf and Bavistin spray (0.29 g) and the highest root weight/plant was recorded from BAU-Biofungicide spray (0.40 g). In case of shoot weight/plant, the highest shoot weight/plant was recorded when treated with BAU-Biofungicide spray (1.63 g) and the lowest shoot weight/plant was found in extract of datura leaf and Bavistin spray (1.22 g) respectively. Similar observations have also been made by Shamsuzzaman *et al.,* (2003), Hossain and Shamsuzzaman (2003) and Rao (2009). Rao (2009) found that plant growth parameters, such as root length, shoot length, shoot fresh weight, shoot dry weight, nodule number and nodule weight of groundnut cultivars were significantly increased after foliar application of Bavistin. BAU-Biofungicide resulted an increase of shoot length, root length, shoot weight, root weight and vigour index of the vegetables seedlings (Hossain *et al.,* 2009).

All treatments gave significant increase in plant height and number of leaves/plant over control (Table 2). The plant height varied within the range of 8.89 to 10.09, 13.22 to 15.11, 27.00 to 31.83, 40.67 to 49.50 and 46.89 to 57.61 cm, respectively at the 1st, 2nd, 3rd, 4th and 5th counts, respectively. In case of the 1st count, maximum plant height was recorded from the treatment with BAU-Biofungicide as seed treatment + spray. The plant height under different treatments in the 2nd count, the highest plant height was recorded from BAU-Biofungicide as seed treatment and BAU-Biofungicide spray. At the 3rd count, maximum plant height was produced by BAU-Biofungicide spray, which was statistically similar to BAU-Biofungicide as seed treatment (31.55 cm). In 4th count, maximum plant height was recorded from the treatment with BAU-Biofungicide as seed treatment + spray. The highest plant height was recorded from debdaru leaf extract at the 5th count. BAU-Biofungicide as seed treatment + spray, BAU-Biofungicide spray and BAU-Biofungicide as seed treatment showed statistically similar efficacy at the 5th count.

In case of the 1st count, the number of leaves/plant ranged 44.00 to 50.56. Maximum total number of leaves/plant was recorded from the treatment with BAU-Biofungicide as seed treatment + spray. The number of leaves/pant under different treatments in the 2nd count varied from 85.56 to 100.78. The highest number of leaves/plant was recorded from spray with extract of datura leaf. At the 3rd count, maximum number of leaves/plant was produced by BAU-Biofungicide as seed treatment (187.67) and BAU-Biofungicide spray (187.56). At the 4th and 5th counts, maximum number of leaves/plant was recorded from the treatment with BAU-Biofungicide as seed treatment + spray by 297.78 and 362.11, respectively. The comparative effects of three different selected botanicals, Bavistin and BAU-Biofungicide on number of infected leaves/plant of groundnut are presented in Table 3. Maximum number of infected leaves/plant was recorded under untreated control at all the five counts. Minimum infected leaves were recorded from Bavistin treated plot followed by extracts of datura, BAU-

Biofungicide as seed treatment + spray and BAU-Biofungicide spray treated plots at all the counts. Extract of neem leaf showed similar effects of Bavistin in the 1st and 2nd counts, respectively.

Total leaf area diseased (%) differed significantly and ranged from 0.59 to 0.93 at the 1st, 0.83 to 1.19 at the 2nd, 1.47 to 1.94 at the 3rd, 4.22 to 7.17 at the 4th and 5.28 to 8.17 at the 5th counts (Table 3). In case of the 1st count, maximum percentage of leaf area diseased was found in the extract of Datura leaf. Maximum percentage of leaf area diseased was recorded from untreated control at 2nd, 3rd, 4th and 5th counts. Minimum percentages of leaf area diseased were obtained with BAU-Biofungicide as seed treatment + spray followed by Bavistin in all the five counts. Bdliya and Alkali (2010) found that the botanicals namely neem seed, garlic clove, onion bulb, ginger rhizome and pawpaw leaf led to about 3-10% reduction in the disease incidence, 10-15% reduction in disease severity than the control. They stated that all the plant extracts reduced the incidence and severity of *Cercospora* leaf spot compared to the untreated crops.

The effects of three different selected botanicals, Bavistin and BAU-Biofungicide on number and weight of total pods/plant, mature pods/plant, immature pods/plant of groundnut cv. Dhaka-1 were determined. The results are presented in Table 4. The number of pods/plant ranged 19.77 to 26.55. Significantly maximum number of pods/plant was recorded from Bavistin treatment followed by extract of neem leaf, BAU-Biofungicide spray and BAU-Biofungicide as seed treatment + spray where the lowest was found under untreated control (Table 4). The number of mature pods/plant ranged 16.50 to 23.16. The highest number of mature pods/plant was recorded under extract of neem leaf treatment followed by extract of debdaru leaf spray, Bavistin spray. The lowest number of mature pods/plant was found under control. Significantly the lowest numbers of immature pods per plant were produced by the treatment BAU-Biofungicide as seed treatment (2.28). All the treatments gave significant increase in total and mature pod weight over control. All the treatments total weight of pods/plant range 13.05 to 20.05 g/plant. Maximum weight of pods/plant was achieved with BAU-Biofungicide as seed treatment + sprays followed by extract of neem leaf spray. The weight of mature pods/plant varied from 11.55 to 18.55 g/plant. The highest weight of mature pods/plant was recorded under BAU-Biofungicide as seed treatment + spray leaf spray which was statistically similar with the treatment of extract of neem leaf and BAU-Biofungicide spray. The weight of immature pods/plant varied from 1.33 to 1.72 g/plant. The lowest weight of immature pods/plant was recorded under extract of debdaru leaf, which was statistically similar to BAU-Biofungicide as seed treatment and BAU-Biofungicide spray.

The effects of three different selected botanicals, Bavistin and BAU-Biofungicide on yield of pod and (%) pod yield increased over control of groundnut. The results are presented in Table 4. Pod yield of groundnut significantly increased over control due to application of all the treatments. The pod yield ranged 3916.7 to 6016.7 kg/ha. The highest and the lowest pod yield were produced by BAU-Biofungicide as seed treatment + spray and untreated control, respectively. The highest pod yield increase was found from the treatment with BAU-Biofungicide as seed treatment + spray followed by extracts of neem leaf, BAU-Biofungicide spray, extracts of datura leaf, BAU-Biofungicide as seed treatment, Bavistin spray and extracts of debdaru leaf. For instance, the highest (53.61%) pod yield increase was recorded from extract of BAU-Biofungicide spray +seed treatment followed by extract of neem leaf (51.91%), BAU-Biofungicide spray (48.51%), datura leaf (40.85%), BAU-Biofungicide as seed treatment (40.42%), Bavistin spray (40.42%) and debdaru leaf (38.72%). Observation made by Hossain and Rahman, (2007) and Bdliya and Alkali (2010) also support the present study.

The Benefit-Cost Ratio analysis of three different selected botanicals, Bavistin and BAU-Biofungicide used for controlling leaf spot of groundnut. The results are presented in Table 5. The results revealed a positive return from the use of materials to control leaf spot of the crop as indicated by the Benefit-Cost Ratio (BCR) and the profit per hectare. The yield increase due to the application of BAU-Biofungicide as spray +seed treatment gave the highest net profit of Tk. 176768.00/ha that was following by extracts of neem leaf Tk. 172275.00/ha, BAU-Biofungicide spray Tk.

168818.00/ha, BAU-Biofungicide as seed treatment Tk. 159725.00/ha, datura leaf Tk. 155043.00/ha, Bavistin spray Tk. 153525.00/ha and debdaru leaf Tk. 153307.00/ha. The percentage of return over control ranged 58.96 to 83.28%. Maximum of 83.28% return over control was obtained from BAU-Biofungicide as seed treatment + spray followed by extract of neem leaf (78.62%), BAU-Biofungicide spray (75.04%), BAU-Biofungicide as seed treatment (65.61%), extract of datura leaf (60.76%) and Bavistin (59.18%). The lowest return over control was obtained from debdaru leaf (58.96%). The lowest profit of Tk. 96443.00/ha was obtained from untreated control. Maximum Benefit-Cost Ratio (BCR) of 1: 2.77 was achieved with BAU-Biofungicide as seed treatment + spray, which was followed by BAU-Biofungicide as seed treatment (1: 2.65), BAU-Biofungicide spray (1: 2.64), extracts of neem leaf (1: 2.62), debdaru leaf (1: 2.39), datura leaf (1: 2.36) and Bavistin (1: 2.30). The minimum of 1: 1.60 Benefit-Cost Ratio (BCR) ration was obtained from untreated control (Table 5).

Summary and Conclusion

The efficacy of three botanicals viz. neem leaf (*Azadirachta indica*), debdaru leaf (*Polyalthia longifolia*), and datura leaf (*Datura metel*), BAU-Biofungicide along with a check (Bavistin) and untreated control were evaluated as foliar spray in the field. Among the treatments, BAU-Biofungicide, extracts of neem leaf, datura leaf and debdaru leaf showed excellent performance in controlling leaf spot and increasing pod yield by 53.61, 51.91, 40.85 and 38.72%, respectively as compared to control in the field. In case of seedling germination, BAU-Biofungicide as seed treatment+ spray gave 97.77% germination followed by extracts of debdaru leaf (95.55%), datura leaf (93.33%) and neem leaf (88.14%). BAU-Biofungicide as seed treatment+ spray produced higher length and weight of shoot and root and vigour index as compared to control. Maximum vigour index was observed under BAU-Biofungicide spray (1583.88). BAU-Biofungicide as seed treatment+ spray gave higher plant height, number of leaves and minimum number of infected leaves in the field as compared to control. Minimum percentages of leaf area diseased were obtained with BAU-Biofungicide as seed treatment + spray followed by Bavistin in the field. BAU-Biofungicide, extracts of neem leaf, datura leaf and debdaru leaf showed promising performance in number and weight of pods and pod yield in the field. Maximum weight of pods/plant and weight of mature pods/plant was achieved with BAU-Biofungicide as seed treatment + sprays (20.05 g and 18.55 g) followed by extract of neem leaf spray (19.83 g and 18.22 g). The highest net profit was recorded with the use of BAU–Biofungicide as seed treatment + foliar spray by Tk. 176768.00/ha followed by extracts of neem leaf Tk. 172275.00/ha, BAU-Biofungicide spray Tk. 168818.00/ha, while the lowest Tk. 96443.00/ha in untreated control. Maximum Benefit-Cost Ratio (BCR) 1: 2.77 was found in BAU–Biofungicide as seed treatment + spray followed by BAU–Biofungicide as seed treatment (1: 2.65), BAU–Biofungicide spray (1: 2.64) and extracts of neem leaf (1:2.62).

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Table 1. Effect of three different selected botanicals, Bavistin and BAU-Biofungicide on Germination (%), Average root length/plant, Average shoot length/plant, Vigor Index, Average root weight/plant, Average shoots weight/plant of groundnut in the field

Botanicals/BAU-Biofungicide with dose	Germination (%)	Average root length/plant (cm)	Average shoot length/plant (cm)	Vigour Index	Average root weight/plant (g)	Average shoot weight/plant (g)
Datura leaf (spray) (20%)	93.33bc	5.46bc	9.74	1419.46	0.29	1.22
Neem leaf (spray) (25%)	88.14d	6.46a	9.03	1363.90	0.37	1.33
Debdaru leaf (spray) (20%)	95.55ab	5.16c	9.05	1362.35	0.29	1.29
BAU-Biofungicide (seed treatment) (3%)	94.07bc	6.18ab	9.38	1463.83	0.37	1.37
BAU-Biofungicide (spray) (3%)	94.81ab	6.20ab	10.51	1583.88	0.40	1.63
BAU-Biofungicide (seed treatment + spray) (3%)	97.77a	6.07abc	9.74	1545.55	0.33	1.33
Bavistin (check) (0.1%)	94.07bc	5.92abc	9.48	1448.96	0.29	1.22
Control	91.11cd	5.38bc	9.57	1366.84	0.33	1.40
Level of significance	**	*	NS	NS	NS	NS

Data represent the means of three replications. Means having common letter (s) do not differ significantly.

** = 1% level of significance

* = 5% level of significance

NS = Not significant

Table 2. Effect of three different selected botanicals, Bavistin and BAU-Biofungicide on plant height and number of leaves/plant of groundnut in the field

Botanicals/BAU-Biofungicide with dose	Plant height (cm) at different counts					Total number of leaves/plant at different counts				
	1st	2nd	3rd	4th	5th	1st	2nd	3rd	4th	5th
Datura leaf (spray) (20%)	9.22	14.50ab	28.78bcd	45.78b	52.17bc	44.00c	100.78a	167.45c	269.67c	329.89e
Neem leaf (spray) (25%)	9.17	13.61bc	30.05abc	46.67ab	53.00abc	44.44c	85.56e	176.44b	281.33b	339.67d
Debdaru leaf (spray) (20%)	9.67	13.94abc	30.00abc	47.89ab	57.61a	47.89ab	90.44d	178.34b	282.33b	344.11c
BAU-Biofungicide (seed treatment) (3%)	9.64	15.11a	31.55ab	48.61ab	54.55ab	48.89ab	98.00ab	187.67a	287.00b	347.33bc
BAU-Biofungicide (spray) (3%)	10.08	15.11a	31.83a	49.17b	55.72ab	48.22ab	95.00bc	187.56a	287.22b	348.33b
BAU-Biofungicide (seed treatment + spray) (3%)	10.09	14.22abc	29.89abc	49.50a	56.72ab	50.56a	95.11bc	174.00b	297.78a	362.11a
Bavistin (check) (0.1%)	8.89	14.08abc	28.34cd	43.00c	49.56cd	44.39c	90.44d	176.44b	259.56d	325.11f
Control	9.81	13.22c	27.00d	40.67c	46.89d	46.61bc	91.55cd	165.78c	251.00e	300.45g
Level of significance	NS	**	**	**	**	**	**	**	**	**

Data represent the means of three replications. Means having common letter (s) do not differ significantly.

** = 1% level of significance

* = 5% level of significance

NS = Not significant

Table 3. Effect of three different selected botanicals, Bavistin and BAU-Biofungicide on number of infected leaves/plant and % leaf area diseased of groundnut in the field

Botanicals/BAU-Biofungicide with dose	Number of infected leaves/plant at different counts					% Leaf area diseased at different counts				
	1st	2nd	3rd	4th	5th	1st	2nd	3rd	4th	5th
Datura leaf (spray) (20%)	5.22bc	9.50a	21.22a	55.95	71.57c	0.93a	1.33a	1.64cde	6.11ab	6.83bc
Neem leaf (spray) (25%)	4.67c	7.11c	21.00a	59.61	74.72b	0.86b	1.19ab	1.83ab	5.89b	7.11ab
Debdaru leaf (spray) (20%)	6.22ab	8.28b	22.33a	66.72	82.28a	0.83b	1.19ab	1.75bc	5.78b	6.94ab
BAU-Biofungicide (seed treatment) (3%)	6.06ab	7.89bc	21.05a	66.00	83.00a	0.72c	0.92b	1.67bcd	4.56cd	5.59cd
BAU-Biofungicide (spray) (3%)	5.83abc	6.83c	20.28a	66.05	83.28a	0.72c	0.94b	1.53de	5.48bc	6.42bcd
BAU-Biofungicide (seed treatment + spray) (3%)	3.44d	6.94c	15.61b	58.17	73.72b	0.61d	0.89b	1.47e	4.22d	5.28d
Bavistin (check) (0.1%)	5.00bc	6.78c	15.62b	51.06	67.61d	0.59d	0.83b	1.53de	4.55cd	5.39d
Control	6.72a	10.56a	21.95a	65.28	80.72a	0.75c	1.36a	1.94a	7.17a	8.17a
Level of significance	**	**	**	NS	**	**	**	**	**	**

Data represent the means of three replications. Means having common letter (s) do not differ significantly.

** = 1% level of significance

* = 5% level of significance

NS = Not significant

Table 4. Effect of three different selected botanicals, Bavistin and BAU-Biofungicide on number, weight of pods/plant and pod yield and (%) pod yield increased over control of groundnut in the field

Botanicals/BAU-Biofungicide with dose	Number of pods/plant			Weight of pods/plant (g)			Pod yield (kg/ha)	(%) pod yield increased over control
	Total pods	Mature pods	Immature pods	Total pods	Mature pods	Immature pods		
Datura leaf (spray) (20%)	25.16	20.33	4.83a	18.39ab	16.66ab	1.72a	5516.7ab	40.85
Neem leaf (spray) (25%)	26.38	23.16	3.22bcd	19.83a	18.22a	1.61ab	5950a	51.91
Debdaru leaf (spray) (20%)	25.61	23.05	2.55de	18.11ab	16.77ab	1.33c	5433.3ab	38.72
BAU-Biofungicide (seed treatment) (3%)	24.39	22.11	2.28e	18.33ab	16.89ab	1.44bc	5500ab	40.42
BAU-Biofungicide (spray) (3%)	26.33	22.72	3.61b	19.39ab	17.94a	1.44bc	5816.7ab	48.51
BAU-Biofungicide (seed treatment + spray) (3%)	25.11	22.39	2.72cde	20.05a	18.55a	1.50bc	6016.7a	53.61
Bavistin (check) (0.1%)	26.55	23.05	3.50bc	18.33ab	16.83ab	1.50bc	5500ab	40.42
Control	19.77	16.50	3.28bcd	13.05b	11.55b	1.50bc	3916.7b	
Level of significance	NS	NS	**	**	**	**	*	

Data represent the means of three replications. Means having common letter (s) do not differ significantly.

** = 1% level of significance

* = 5% level of significance

NS = Not significant

Table 5. Benefit –Cost Ratio (BCR) analysis for five sprays with three different selected botanicals, Bavistin and BAU-Biofungicide for controlling leaf spot of groundnut in the field

Functions	Datura leaf (spray)	Neem leaf (spray)	Debdaru leaf (spray)	BAU-Biofungicide (seed treatment)	BAU-Biofungicide (spray)	BAU-Biofungicide (seed treatment + spray)	Bavistin (check)	Control (untreated)
Seed (Tk.)	5500.00	5500.00	5500.00	5500.00	5500.00	5500.00	5500.00	5500.00
Preparation of land (Tk.)	11000.00	11000.00	11000.00	11000.00	11000.00	11000.00	11000.00	11000.00
Planting (Tk.)	6000.00	6000.00	6000.00	6000.00	6000.00	6000.00	6000.00	6000.00
Cost of fertilizer and its application (Tk.)	8550.00	8550.00	8550.00	8550.00	8550.00	8550.00	8550.00	8550.00
Weeding (Tk.)	4800.00	4800.00	4800.00	4800.00	4800.00	4800.00	4800.00	4800.00
Cost of treatments (Tk.)	2400.00	2500.00	800.00	50.00	625.00	675.00	3250.00	-
Spraying cost (Tk.)	3000.00	3000.00	3000.00	-	3000.00	3000.00	3000.00	-
Spray of insecticide cost (Tk.)	2175.00	2175.00	2175.00	2175.00	2175.00	2175.00	2175.00	2175.00
Cost of harvesting and carrying (Tk.)	7200.00	7200.00	7200.00	7200.00	7200.00	7200.00	7200.00	7200.00
Cost of processing (Tk.)	12000.00	12000.00	12000.00	12000.00	12000.00	12000.00	12000.00	12000.00
Transportation (Tk.)	3000.00	3000.00	3000.00	3000.00	3000.00	3000.00	3000.00	3000.00
Total cost of cultivation (Tk.)	65625.00	65725.00	64025.00	60275.00	63850.00	63900.00	66475.00	60225.00
Income: Yield (kg/ha)	5516.7	5950	5433.3	5500	5816.7	6016.7	5500	3916.7
Sell price (Tk /ha)	220668.00	238000.00	217332.00	220000.00	232668.00	240668.00	220000.00	156668.00
Profit (Tk/ha)	155043.00	172275.00	153307.00	159725.00	168818.00	176768.00	153525.00	96443.00
(%) retune over control	60.76	78.62	58.96	65.61	75.04	83.28	59.18	-
cost –Benefit ratio	1:2.36	1:2.62	1:2.39	1:2.65	1:2.64	1:2.77	1:2.30	1:1.60

Legends: Labour cost: Tk.200/labour, Seed cost: Tk. 50/kg, Cost of Bavistin: Tk.1300/kg, Cost of neem leaf: Tk. 5.0/kg, Cost of datura leaf: Tk. 6.0/kg, Cost of debdaru leaf: Tk. 4.0/kg, Cost of BAU-Biofungicide: 100/kg, Fertilizer cost: Urea Tk. 20/Kg, TSP: Tk. 25/kg, MoP: Tk.28/kg and sell prize of groundnut: Tk.40.0/kg

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