

INTEGRATED MANAGEMENT OF PURPLE BLOTCH DISEASE COMPLEX FOR ONION SEED PRODUCTION IN BANGLADESH

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Abstract

Onion suffers from many diseases and among them purple blotch complex is devastating for both bulb and seed production in Bangladesh. To formulate an integrated approach for its management, different IPM components viz. three fungicides viz. Rovral 50 WP (Iprodione), Dithan M-45 (Mancozeb) and Score 250 EC (Difconazole); two botanicals viz. Alamanda leaf extract (*Allamanda cathartica*) and Neem leaf extracts (*Azadiracta indica*); four soil amendments viz. Poultry manure, bioagent, saw dusts and micronutrients (Zn @ 0.45/L +B @ 2.5g/L) were evaluated under field condition. The experiment was conducted at the farm of Sher-e-Bangla Agricultural University, Dhaka, during 2011-2012. Pathogenicity test indicated that *Alternaria porri* and *Stemphylium vesicarium* were the pathogens where *S. vesicarium* initiated the infection and *A. porri* facilitated the subsequent infection and made a complex form of disease. Among the chemical fungicides, Score 250 EC was found promising followed by Rovral 50 WP against purple blotch complex in terms of reduction of disease incidence and severity ultimately contributing to increased yield (134% and 129%, respectively) over control. Among botanicals, Alamanda leaf extract produced better result compared to neem leaf extract (99.6% and 67.6% respectively). In terms of increasing yield, poultry manure showed better performance (72.3%) followed by micronutrient (69.5%) and bioagent (58.2%).

Keywords: *Allium cepa* L., *Alternaria porri*, Integrated management, Purple blotch complex, Seed production, *Stemphylium vesicarium*

Introduction

Onion is a popular vegetable in Asia and very common and favorite spices in Bangladesh. Our annual requirement of onion bulb ranges between 2.2 and 2.5 million tons whereas Bangladesh produces 19.54 lac metric tons from 185346 hectare of land (BBS 2020). In the country, Faridpur is the second-biggest onion-producing district, followed by Pabna. In Bangladesh, farmers produce about 700 tons of onion seeds annually, and Faridpur accounts for 60-65 per cent of the production (Das, 2021). Thus, a deficit of onion bulb for consumption and seed bulb for production per annum creates

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market crisis among the onion farmers in the growing season in Bangladesh. The government meets up the deficit of bulb and onion seed by importing from neighboring countries in exchange of foreign currency.

Onion suffers from different diseases like purple blotch, seed rot, black mould, damping off and white blotch or *Stemphylium* blight (Fakir, 2002). Among the diseases, purple blotch of onion caused by *Alternaria porri* and white blotch of onion caused by *Stemphylium vesicarium* are presently considered as the most damaging diseases both for bulb and seed production. In many occasions, these two diseases simultaneously attack the onion crop and make a complex form of disease which is known as 'purple blotch disease complex' of onion. This disease is most devastating and affects both bulb yield and seed production all over the world including Bangladesh (Islam et al., 2001 and Mishra and Gupta, 2012). In Bangladesh, it has been reported as 41-44% yield losses of onion due to this disease (Fakir, 2002). The fungi *A. porri* and *S. vesicarium* produce injurious toxin and metabolites, which affect seed germination and seedling growth (Lou et al., 2013).

The present concept of plant disease management is to maintain the pest population below the economically damaging level by integrated management practice(s) rather it eliminates entirely from the environment by using toxic chemicals. Hence, attempts to be made to evaluate different treatments including eco-friendly components along with fungicides to manage the disease. Based on the above facts the present research was undertaken to evaluate different treatments to formulate integrated disease management of purple blotch disease complex of onion for seed production in the field.

Materials and Methods

Experimental site

The field experiments were conducted at the farm of Sher-e-Bangla Agricultural University (SAU), Dhaka-1207.

Soil type

The soil of the experimental site belonged to the agro-ecological region of "Madhupur Tract" (AEZ No. 28). It was Deep Red Brown Terrace soil and belongs to "Nodda" cultivated series. The top soil was clay loam in texture. Organic matter content was very low (0.82%) and soil pH varied from 5.47-5.63.

Experimental period

The experiments were conducted during November 2011 to March 2012.

Experimental design and data analysis

Completely Randomized Design (CRD) was exercised with 4 replications for Laboratory experiments and Randomized Complete Block Design (RCBD) with 4 replications was used for field experiments.

Treatment of onion bulb

The onion bulbs were treated for each treatment with the respective plant extracts and fungicidal solutions by dipping the bulbs in the suspension for 15 minutes before plantation. The bulbs were then drained off, shade dried and sown in the field without delay. For control treatment the bulbs were treated with plain water only. Bulbs of onion were planted on 15 November' 2011 maintaining row spacing of 25 cm and bulb spacing of 20 cm in each plot.

Preparation of plant extracts solution

The plant extracts were prepared by using the method of Islam (2005). For this purpose, collected leaves/rhizome/bulb were weighed in an electric balance and then washed in the tap water. After washing, the big leaves/rhizome/bulb was cut into small pieces. For getting extract, weighed plant parts were blended in an electric blender adding required amount of water. The pulverized mass was squeezed through cheese cloth. For getting 1:2 (w/v) ratio 200 ml of distilled water was added with 100 g plant parts. This solution was used in field trial.

Treatments

Altogether 10 different treatments comprising different plant extracts, fungicides, bioagent and soil amendments were explored in this experiment were stated below:

- T₀ = Control (Bulb treatment with plain water followed by foliar spraying with the same)
- T₁ = Rovral 50 WP - Ipridione 50% (Bulb treatment @ 2g/L+ Foliar spraying @ 2g/L)
- T₂ = Dithane M-45- Mancozeb 45% (Bulb treatment @ 4.5g/L+ Foliar spraying @ 4.5g/L)
- T₃ = Score 250 EC- Difenconazol 25% (Bulb treatment @ 0.5g/L+ Foliar spraying @ 0.5g/L)
- T₄ = Alamanda (*Allamanda cathartica*) leaf extract - S/N (Bulb treatment @ 1:2 (w/v)+ Foliar spraying @ 1:2 (w/v))
- T₅ = Neem (*Azadirachta indica*) leaf extract - S/N (Bulb treatment @ 1:2 (w/v)+ Foliar spraying @ 1:2 (w/v))
- T₆ = Soil amendment with Bioagent- *T. harzianum*, (Basal application @ 2.5kg/ha+ Foliar spraying @ 5g/L)
- T₇ = Soil amendment by Poultry manure @ 60t/ha
- T₈ = Soil amendment by Saw dust @ 60t/ha
- T₉ = Soil amendment by Micronutrient (Zn @ 0.45g/L +B @ 2.5g/L)

Isolation and identification of *A. porri* and *S. vasicarium* from infected leaf sample of onion

For isolation of causal pathogens, diseased specimens were collected from the major onion growing areas of the country. Isolation done by tissue planting method and single spore/tip culture method was followed to purify the epagoges. The diseased leaves were cut

into pieces (5mm diameter) and surface sterilized with HgCl_2 (1: 1000) for 30 seconds. The cut pieces were washed in sterile water thrice and were placed on acidified PDA medium in petridish. The plates containing leaf pieces were incubated at room temperature for seven days. When the fungi grew well and sporulated, then the organisms were re-cultured by single spore or tip culture method to obtain pure culture. Identification of the pathogen was done under compound microscope by making slides from the pathogenic culture. The pathogens, *A. porri* and *S. vasicarium* were identified with the help of relevant literature depending on physical structure and fruiting body (Ellis, 1971).

Preparation of inoculums for pathogenicity study

The conidia suspension of *Alternaria porri* and *Stemphylium vesicarium* were prepared with sterilized water using 10 days and 30 days old PDA culture and then incubated at 22-24°C under NUV light and dark cycle (12/12). The suspension was sieved through a double layered of cheese cloth to remove mycelia fragments and conidiophores. One drop of tween-20 (polyoxyethylene 20 sorbitan monolaurate) was added to the suspension to maintain uniform dispersion of conidia in suspension. The concentrations of conidial suspensions were 21×10^5 per ml and 14×10^2 per ml, respectively for *Alternaria porri* and *Stemphylium vesicarium*.

Inoculation on onion plant

The inoculations were done with the respective spore suspension individually and in combination. In case of combined inoculation the spore suspension was mixed with 1:1 proportion. The inoculated plants were covered with transparent polyethylene sheet for 48 hours to keep the inside moist and humid (% RH) for infection and also to prevent natural contamination with other organisms. The plants were kept in a net house at $25 \pm 2^\circ\text{C}$ for observation. For pathogenicity study, the isolation, re-isolation, observation and recording symptoms of pathogenic characteristics were done following Koch's postulate (Koch, 1891) to confirm the pathogenicity of the organisms.

Inoculation by *A. porri* and *S. vasicarium* and field spray

After germination of onion bulb, inoculation was done by the purple blotch complex pathogen, *A. porri* and *S. vasicarium* to ensure infection at an amount of pathogenicity test. Spraying of fungicides, plant extracts and bioagent were started from 36 days after bulb planting. Totally ten spraying were done at 7 days intervals with a hand sprayer.

Data collection and analysis

Twelve plants were selected randomly for each plot and tagged for data collection. Data collection was started after the onset of the disease and expression of symptoms and continued up to maturity of the crop with 7 days intervals. Data were collected on the parameters (disease incidence, leaf and stalk area diseased, disease severity, numbers of umbels per plot, diameter of umbel, weight of 1000 seeds). Complete package program MSTAT-C was used for analysis of all related data. Duncan's Multiple Range Test (DMRT) was explored for comparison of means (Gomez and Gomez, 1983).

Estimation of disease incidence

Number of infected leaves and number of infected floral stalk were recorded for calculation of disease incidence. The leaf with characteristic purple colored spot or blighted tip was denoted as diseased leaf. The percent disease incidence was calculated using the following formula (Wheeler, 1969):

$$\% \text{ Leaf infection} = \frac{\text{Number of leaf infected plant}}{\text{Total number of inspected plant}} \times 100$$

$$\% \text{ Stalk infection} = \frac{\text{Number of infected stalk}}{\text{Total number of inspected stalk}} \times 100$$

Leaf and stalk area diseased (LAD/SAD)

Leaf and stalk area diseased of the selected plants in every unit plot under each treatment were measured and recorded by conversion to percentage. Mean percentage of leaf and stalk area diseased were calculated by dividing number of total observation. Percentage of leaf and stalk area diseased were used to calculate the disease severity. The % LAD and % SAD were calculated using the following formula (Wheeler, 1969):

$$\% \text{ LAD or } \% \text{ SAD} = \frac{\% \text{ Leaf/Stalk area infected}}{\% \text{ Leaf/Stalk area inspected}} \times 100$$

Estimation of disease severity

The percent disease index (PDI) was calculated using the following formula (Wheeler, 1969):

$$\text{PDI (Leaf/stalk)} = \frac{\text{Total sum of numerical ratings}}{\text{Total No. of observation} \times \text{Maximum grade in the scale}} \times 100$$

The disease severity was calculated as PDI (Percent Disease Index) using '0 - 5' scale proposed by Horsfall and Barrett (1945) as stated below:

% Leaf/ Stalk area diseased	Grade/Ratting	Description
0	0	No disease symptoms
0.1 - 5.0	1	A few spots towards the tip covering 0.1 - 5.0 % leaf/stalk area diseased
5.1 - 12.0	2	Several purple-white patches covering less 5.1 - 12.0 % leaf/stalk area diseased
12.1 - 25.0	3	Several purple-white patches covering 12.1 - 25.0 % leaf /stalk area diseased
25.0 - 50	4	Long purple-white patches covering 25.0 – 50 % leaf /stalk area diseased
> 50	5	More than 50 % leaf/stalk area blotched and causing breaking of leaf/stalk.

Harvesting of umbels and seeds

Onion seeds were harvested on 30th March 2012. After drying of umbel, threshing, winnowing and cleaning of onion seeds were done. Later weight of seed for each unit plot under each treatment was taken separately and recorded. Numbers of umbels per plot, Diameter of umbel, Weight of 1000 seeds were measured and recorded. Seed yield was recorded after converting it to kg/ha.

Results and Discussion

Pathogenicity test of the purple blotch complex pathogens

On inoculation with spore suspension of *A. porri* and *S. vesicarium* the characteristic symptoms of purple blotch complex on onion leaf was observed after ten days of incubation. On re-isolations from diseased portion of artificially inoculated plants, the same causal organisms were found with similar cultural properties of original ones. The pathogenicity test revealed that the isolates produced purple and white blotch of onion on inoculation and the same organisms were found on re-isolation from the artificially produced diseased plant. Islam *et al.*, 2001 reported that *A. porri* and *S. vesicarium* are involved in causing purple blotch complex of onion. They also stated that *S. vesicarium* initiated the infection causing white blotch which facilitated the subsequent infection of *A. porri* causing purple blotch and made the disease in complex form.

Effect of different treatments on disease incidence (% leaf infection)

The effect of different fungicides, botanicals and soil amendments on leaf infection differed significantly at different days after planting (DAP) (Table 1). At 99 DAP, the lowest leaf infection was recorded for the treatment T₃ (28.65%) followed by treatment T₁ (29.25%), while the highest leaf infection was recorded for the control treatment T₀ (99.58%). From the botanicals, Alamanda leaf extract gave better performance (76.93%) for controlling purple blotch complex of onion followed by Neem leaf extract (82.35%). In case of soil amendments, poultry manure gave better performance (82.46%) followed by bioagent (9.57%), micronutrient (93.21%) and sawdust (97.62%).

Effect of different treatments on disease severity (PDI-leaf)

Table 2 shows that the lowest PDI (19.22 %) was observed in treatment T₃ followed by T₁ (20.52%) and T₂ (38.93%). However, the highest leaf severity was recorded in untreated control plot, T₀ (98.72%). Alamanda leaf extract (T₄) gave lower PDI (52.36%) followed by Neem leaf extract (T₅) 65.50%. In case of soil amendments, poultry manure (T₇) showed better performance (58.62%) followed by bioagent (T₆) 74.43%, micronutrient (T₉) 79.50% and sawdust (T₈) 86.25%. At 99 DAP, the percent decrease of disease severity were 80.53% and 79.21%, respectively, over untreated control.

Effect of different treatments on disease incidence (% stalk infection)

At 136 DAP, the lowest infection (15.98%) was found in treatment T₃ which was statistically similar to T₁ (17.48%). The highest stalk infection (87.19%) was recorded in

control treatment (T₀) which was similar to treatment T₈ (87.05%). In case of botanicals, allamanda leaf extract (T₄) showed comparatively better performance than Neem leaf extract (T₅). Soil amendments showed significant differences among themselves. The lowest % stalk infection was found in poultry manure (T₇ = 68.81%) followed by micronutrient (T₉ = 71.80%), bioagent (T₆ = 71.81%) and sawdust (T₈ = 87.05%) (Table 3).

Table 1. Effect of different treatments on % leaf infection of purple blotch complex of onion in the field at different days after planting (DAP)

Treatments	% Infected leaf at different days after planting (DAP)										% decrease of disease incidence over control at 99 DAP
	36 DAP	43 DAP	50 DAP	57 DAP	64 DAP	71 DAP	78 DAP	85 DAP	92 DAP	99 DAP	
T ₀	33.74 a	48.92a	61.41 a	68.64 a	73.62 a	74.15 a	78.64 a	81.56 a	97.72 a	99.58 a	-
T ₁	21.58 h	22.55h	23.37 i	24.13 i	25.15 h	26.00 g	26.98 g	27.84 h	28.43 i	29.25 h	70.63
T ₂	24.70g	38.83e	44.53g	48.52 g	55.25f	54.44f	58.48f	58.34 g	57.24 h	71.67 g	28.03
T ₃	21.07 h	23.45g	24.39 h	25.61 h	26.36 g	27.60 g	27.84 g	28.10 h	28.33 i	28.65 h	71.23
T ₄	26.36f	36.23f	47.62f	52.68 f	58.59e	57.22 e	57.01fg	60.50f	71.46 f	76.93 f	22.75
T ₅	28.74d	41.55d	50.53e	57.92d	61.70d	61.49 d	63.30e	69.49d	83.28 d	82.35 e	17.30
T ₆	29.65c	44.78c	53.64d	63.78c	64.53c	64.31c	65.23d	75.47c	86.73 c	89.57 d	10.05
T ₇	27.55e	39.26e	48.33f	54.97e	61.72d	61.36d	58.22f	65.55e	77.09 e	82.46 e	17.19
T ₈	32.19 b	47.42 b	56.74b	68.21a	72.95a	73.81a	74.57 b	80.29 ab	98.17 a	97.62 b	1.97
T ₉	31.86b	45.26 c	55.53c	65.44b	67.28 b	67.60b	69.53c	79.25b	91.55 b	93.21 c	6.40
LSD (0.01)	0.61	0.74	0.86	1.37	1.17	1.40	1.70	1.53	1.47	1.52	
CV (%)	1.11%	0.94%	0.91%	1.27%	1.00%	1.20%	1.42%	1.18%	0.98%	0.97%	

Values in a column with same letter (s) do not differ significantly (p=0.01) by DMRT.

Effect of different treatments on disease severity (PDI-floral stalk)

At 136 DAP, the highest performance of treatment i.e. the lowest PDI (16.73%) was recorded in case of treatment T₃ followed by treatment T₁ (17.65%) which was statistically indifferent. The highest stalk infection was recorded in untreated control plot (98.72%). At 99 DAP, % decreases of disease severity over control was 81.94% and 80.99% respectively. Allamanda leaf extract, (T₄) gave lower PDI (60.51%) than neem leaf extract (T₅= 64.54%). In case of soil amendments, poultry manure (T₇= 61.49%) and bioagent (T₆ = 61.15%) showed statistically similar performance followed by micronutrient (T₉= 85.52%) and sawdust (T₈= 90.36%) (Table 4).

In the field evaluation with 3 different fungicides, Score 250 EC and Rovral 50 WP proved to be the promising fungicides in reducing the disease incidence and severity of purple blotch complex of onion. The disease incidence was reduced by 71.23% and 81.67% in case of Score 250 EC while it was 70.63% and 79.95% in case of Rovral 50

Table 2. Effect of different treatments on disease severity (PDI-Leaf) of purple blotch complex of onion in the field at different days after planting (DAP)

Treatments	Percent disease index (PDI leaf) at different days after planting (DAP)										% decrease of PDI over control at 99 DAP
	36 DAP	43 DAP	50 DAP	57 DAP	64 DAP	71 DAP	78 DAP	85DAP	92DA P	99 DAP	
T ₀	25.21a	29.54 a	35.41a	38.55 a	48.38 a	53.03 a	62.43 a	71.39 a	84.17 a	98.72 a	-
T ₁	11.48 e	12.27 f	13.46 f	14.75 g	16.52 h	17.66 j	18.17 i	19.04 j	19.84 j	20.52 i	79.21
T ₂	15.21 d	17.15 e	19.38 e	20.95 f	23.59 g	25.70 i	29.08 h	32.51 i	36.01 i	38.93 h	60.57
T ₃	11.02 e	12.84 f	13.96 f	15.15 g	16.02 h	16.84 j	17.20 i	17.53 j	18.13 j	19.22 j	80.53
T ₄	17.70c	19.00 d	23.86 d	27.13 e	26.53 f	34.89 g	37.53 f	42.64 g	46.09g	52.36g	46.96
T ₅	20.15 b	23.30 c	27.47 c	29.31 d	34.04 d	39.48 e	46.61 d	51.70 e	61.37e	65.50e	33.65
T ₆	21.38 b	26.13 b	30.32 b	33.4 c	36.02 c	43.20 d	51.63 c	56.53 d	67.57d	74.43d	24.60
T ₇	18.56 c	21.83 c	26.43 c	27.39 e	28.52 e	37.63 f	40.49 e	47.39 f	54.83f	58.62f	40.62
T ₈	24.37 a	28.45 a	35.32 a	38.42 a	47.38 a	49.95 b	61.39 a	67.17 b	79.46b	86.25b	12.63
T ₉	24.04 a	26.52 b	31.62 b	36.24 b	40.44 b	45.61 c	54.49 b	62.72 c	74.44c	79.50c	19.47
LSD (0.01)	1.52	1.56	1.60	1.63	1.86	1.76	1.38	1.54	1.73	1.31	
CV (%)	4.01%	3.58%	3.08%	2.82%	2.85%	2.35%	1.59%	1.58%	1.54%	1.06%	

Values in a column with same letter (s) do not differ significantly (p=0.01) by DMRT.

WP. The PDI reduced by 80.53% and 81.98% in case of Score 250 EC while it was 79.21% and 80.99% in case of Rovral 50 WP (Table 4). Islam (2005) found Score 250 EC as the most effective fungicide next to Rovral 50 WP in reducing mycelial growth of *A. porri*. Islam *et al.*, (2001) also reported that Rovral 50 WP was the most effective fungicide next to Score in reducing radial mycelial growth of *A. porri* in *in-vitro*. Ali (2008) observed that Rovral 50WP @ 0.2% reduced the highest mycelia growth of *A. porri* and *S. vesicarium* followed by Ridomil Gold MZ-72 @ 0.2% and Dithane M-45 @ 0.45% compared to control. Hossain (2008) stated that among seventeen fungicides against purple blotch of onion (*A. porri*), Rovral and Score totally inhibited the mycelial growth of the fungi. Akhter *et al.*, (2015) reported that among the fungicides Rovral 50WP (Iprodione) was found to be the most effective fungicide to retard the radial mycelial growth of *S. botryosum*.

Between two botanicals assayed against the causal pathogens, Alamanda leaf extract was found to be promising in controlling mycelial growth of *A. porri* and *S. vesicarium* as well as reducing the disease incidence and severity. The disease incidence

Table 3. Effect of different treatments on % stalk infection of purple blotch complex of onion in the field at different days after planting (DAP)

Treatments	% Infected stalk at different days after planting (DAP)									% decrease of disease incidence over control at 136 DAP
	80 DAP	87 DAP	94 DAP	101 DAP	108 DAP	115 DAP	122 DAP	129 DAP	136 DAP	
T ₀	4.597 a	6.675 a	12.61 a	19.66 a	26.58 a	36.48 a	53.58 a	78.50 a	87.19 a	
T ₁	2.35 d	2.38 e	3.80 e	4.58 f	7.03 f	8.88 f	11.18 f	13.94 g	17.48 g	79.95
T ₂	3.18 bc	3.53 d	5.59 d	9.72 e	12.82 e	15.26 e	18.87e	21.04 f	26.41 f	69.71
T ₃	2.01 d	2.88 e	4.80 e	5.28 f	7.53 f	9.18 f	12.14 f	13.51 g	15.98 g	81.67
T ₄	3.48 c	5.26 bc	7.27 c	11.45 d	22.43 bc	25.20 c	41.38 c	55.40 e	67.06 e	23.09
T ₅	3.79 ab	5.22 bc	8.53 b	13.52 bc	23.25 b	26.49 bc	43.52 b	58.45 c	70.35 c	19.31
T ₆	3.84 ab	5.58 b	9.29 b	13.65 bc	21.61 c	26.46 bc	43.63 b	60.48 b	71.81 b	17.64
T ₇	3.27 bc	5.44 bc	8.847 b	12.80 c	26.47 a	25.31 c	41.93 c	57.00 d	68.81d	21.08
T ₈	4.60 a	6.65 a	12.60 a	19.40 a	25.65 a	35.59 a	52.99 a	77.57 a	87.05 a	0.16
T ₉	4.38 a	6.22 ab	11.60 a	14.49 b	6.58 f	27.47 b	44.68 b	61.03 b	71.80 b	17.65
LSD (0.01)	0.87	0.99	1.12	1.07	1.55	1.47	1.28	1.25	1.28	
CV (%)	7.23 %	14.55%	8.75%	5.17%	3.53%	2.75%	2.30%	1.51%	1.11%	

Values in a column with same letter (s) do not differ significantly (p=0.01) by DMRT.

was reduced by 22.75% and 23.09% in case of Alamanda leaf extract while it was 17.30% and 17.64% in case of Neem extract. The PDI was reduced by 46.96% and 34.82% in case of Alamanda leaf extract while it was 33.65% and 30.48% in case of Neem extract. Akhter *et al.*, (2015) reported that Alamanda and Neem leaf extract showed positive result against purple blotch disease of onion. In the field evaluation, the performance of Alamanda and Neem leaf extract against the disease was significantly better than control but not so praiseworthy like chemical fungicides Score 250EC and Rovral 50WP. The performance of Alamanda leaf extract was comparatively better than Neem leaf extract in reducing the incidence and severity of purple blotch complex of onion. Tiwari and Srivastava (2004) reported that Neem extract showed antifungal activity against *A. porri* and *S. vesicarium* causing purple blotch and white blight of onion. Tiwari *et al.*, (2002) reported that *A. cathartica* acted as antidermatophilic agent against fungi. Islam *et al.*, (2004) reported that Alamanda leaf extract inhibited even 100% mycelia growth of *Phomopsis vexans* causing phomopsis blight and fruit rot of eggplant. Tiwari and Srivastava (2004) also reported that Neem leaf extract inhibited the growth of the onion pathogens, *A. porri* causing purple blotch of onion and *S. vesicarium* causing white blight of onion. *A. indica* have antifungal activities against *Alternaria sp.* (Bobbarala *et al.*, 2009 and Bhardwaj, 2012).

Table 4. Effect of different treatments on disease severity (PDI-stalk) of purple blotch complex of onion in the field at different days after planting (DAP)

Treatment	Percent disease index-stalk (PDI-stalk) at different days after planting (DAP)									
	80 DAP	87 DAP	94 DAP	101 DAP	108 DAP	115 DAP	122 DAP	129 DAP	136 DAP	% decrease of PDI over control at 136 DAP
T ₀	4.08 ab	5.67 a	9.51 a	18.30 a	24.56 a	34.45 a	51.33 a	70.34 a	92.83 a	
T ₁	1.36 g	1.45 e	2.82 d	3.85 e	5.93 g	8.00 h	10.97 g	14.26 j	17.65 h	80.99
T ₂	1.81 f	3.27 d	3.63 cd	4.51 e	8.67 f	9.40 g	11.45 g	17.45 i	21.45 g	76.89
T ₃	1.25 g	1.49 e	2.32 d	3.58 e	5.03 g	7.15 h	9.97 g	14.00 j	16.73 h	81.98
T ₄	1.97 ef	4.64 a-c	6.26 b	12.35 b	18.56 c	24.62 d	40.44 c	55.53 d	60.51 e	34.82
T ₅	2.62 d	4.28 b-d	6.47 b	11.02 c	17.51 cd	21.98 e	32.36 e	47.56 f	64.54 d	30.48
T ₆	3.49 c	4.57 a-d	6.64 b	10.68 c	21.56 b	29.31 c	36.27 d	52.01 e	61.15 e	34.13
T ₇	2.53 d	4.51 a-d	5.71 b	10.66 c	16.64 d	17.36 f	24.44 f	34.53 h	61.49 e	33.76
T ₈	4.40 a	5.64 a	9.27 a	17.70 a	24.04 a	33.68 a	50.51 a	68.72 b	90.36 b	2.66
T ₉	3.81bc	5.47 ab	9.29 a	18.35 a	23.63 a	31.71 b	48.48 b	65.26 c	85.52 c	7.87
LSD (0.01)	0.40	1.22	1.10	1.15	1.18	1.21	1.49	1.37	1.29	
CV (%)	12.50%	9.85%	6.73%	4.25%	4.02%	3.03%	1.71%	1.20%	1.04%	

Values in a column with same letter (s) do not differ significantly (p=0.01) by DMRT.

Among the four different soil amendments, poultry manure was the promising options for the management of the disease. The disease incidence was reduced by 17.19% and 21.08% respectively in case of poultry manure while it was 10.05% and 17.64% respectively in case of bioagent. The PDI was reduced by 24.60% and 33.76% respectively in case of poultry manure while it was 24.60% and 34.13% respectively in case of Bioagent. Hafiz (2009) reported that for the management of purple blotch of onion soil application with poultry manure found effective. Hasanat (2011) and Bhuiyan (2010) reported that poultry manure had tremendous effect in the management of rhizome rot of ginger caused by *Fusarium oxysporum*. However the action of poultry manure increases the microbial activity of soil borne antagonist that indirectly contributed for the management of the plant pathogens.

Effect of different treatments on yield and yield contributing characters

The effect of fungicides, botanicals and soil amendments on height of seed stalk (cm) of onion that was slightly differed among the treatments and ranged from 46.34 cm to 65.48 cm. At maturity stage, the highest height recorded under treatment T₃ (65.48 cm) and T₁ (64.44 cm) (Table 5). The lowest height was found in untreated control plot (46.34 cm). In case of botanicals, alamanda leaf extract (T₄) gave higher stalk height (56.49 cm) followed by neem leaf extract, T₅ (60.11 cm). In case of soil amendments, bioagent (T₆

=56.41 cm) showed highest height followed by sawdust (T_8 =55.08 cm), micronutrient (T_9 = 54.57 cm) and poultry manure (T_7 = 51.66 cm). The effect of fungicides, botanicals and soil amendments on number of onion seed stalk/hill was insignificant for all the treatments. The highest number of effective umbel/plot recorded under treatment T_3 (92.58) which were statistically similar to treatment T_1 (92.30). The 3rd highest number of effective umbel/plot was recorded in T_2 (84.26) and the lowest number recorded in control treatment T_0 (59.98). In case of botanicals, alamanda leaf extract, (T_4) produced higher number of effective umbel/plot (81.42) followed by neem leaf extract T_5 (72.08). In case of soil amendments, poultry manure T_7 (57.91) and bioagent T_6 (67.43) produced statistically similar number of effective umbel followed by micronutrient T_9 (62.94) and saw dust T_8 (79.33). The umbel diameter (cm) of onion was slightly differed among the treatments that ranged from 5.11 cm to 6.21 cm (Table 5). Significantly the highest umbel diameter (6.21 cm) was recorded under treatment T_3 which was statistically similar to treatment T_1 (6.19 cm), T_2 (6.00 cm) and T_4 (5.44 cm). The lowest umbel diameter was measured in untreated control treatment T_0 (5.11 cm) which was statistically identical with treatment T_6 (5.15 cm), T_7 (5.15 cm), T_9 (5.15 cm), T_8 (5.16 cm) and T_5 (5.15 cm). The highest onion seed yield was recorded under treatment T_3 (600.0 kg/ha) which was statistically identical with treatment T_1 (586.0 kg/ha), T_2 (505.0 kg/ha) and T_4 (511.0 kg/ha). The lowest yield was recorded under treatment T_0 (256.0 kg/ha) preceded by treatment T_5 (429.0 kg/ha), T_9 (434.0 kg/ha) and T_7 (441.0 kg/ha). The highest percent increase of yield (134.34%) over control was recorded under treatment T_3 followed by T_1 (128.91%). The lowest percent of increase of yield over control was recorded under treatment T_8 (55.47%). The present findings of the experiment were well supported by the reports of previous workers (Khatun, 2007; Ahmed, 2007; Ali, 2008; Hossain, 2008; Islam *et al.*, 2001; and, Akhter *et al.*, (2015). Hossain (2000) reported that application of micronutrient (Zinc+Boron) increased considerable seed yield against purple blotch of onion in field condition. Khatun (2007) while conducting a field experiment reported that Rovral 50WP (0.2%) minimized the disease incidence and severity of purple blotch complex of onion and increased bulb yield of onion. Akhter *et al.*, (2015) reported that there was a positive and significant impact of fungicides and plant extracts on plant height, bulb diameter and bulb yield of onion. All the plant parameters were increased with applying different fungicides and plant extracts with their effectiveness. The highest bulb yield (8.767 t/ha) and highest bulb diameter (3.787 cm) were obtained with Rovral treated plot. Antagonistic effect of poultry manure against other plant pathogen is also reported by several researchers (Meah, *et al.*, 2004; Islam, 2005, Bhuiyan, 2010; Hasanat, 2011; Yoldas *et al.*, 2019). Poultry manure increases the microbial activity of soil borne antagonist that indirectly contributes for the management of the plant pathogens.

Table 5. Effect of different treatments on seed yield and yield contributing characters against purple blotch complex of onion

Treatment	Height of onion seed stalk (cm)	No. of onion seed stalk/hill	No. of umbel/plot	Umbel diameter (cm)	1000 Seed weight (gm)	Seed yield (kg/ha)	% Increase of yield over control
T ₀	46.34 f	0.85 a	59.98 h	5.11 b	2.62 a	256 e	-
T ₁	64.44 a	1.40 a	92.30 a	6.19 a	3.43 a	586 a	128.91
T ₂	60.22 b	1.38 a	84.26 b	6.00 ab	3.36 a	505 a-d	97.27
T ₃	65.48 a	1.42 a	92.58 a	6.21 a	3.41 a	600 a	134.38
T ₄	56.49 c	1.38 a	81.42 c	5.44 ab	3.04 a	511 a-c	99.61
T ₅	60.11 b	1.12 a	72.08 e	5.20 b	3.31 a	429 b-d	67.58
T ₆	56.41 c	1.21 a	67.43 i	5.15 b	3.28 a	405 cd	58.20
T ₇	51.66 e	0.99 a	57.91 i	5.15 b	2.44 a	441 b-d	72.27
T ₈	55.08 d	1.36 a	79.33 d	5.16 b	2.79 a	398 d	55.47
T ₉	54.57 d	1.10 a	62.94 g	5.15 b	3.03 a	434 b-d	69.53
LSD (0.01)	1.05	0.58	0.85	0.80	0.99	96.00	
CV (%)	0.95%	24.72%	0.58%	7.47%	16.71%	11.00%	

Values in a column with same letter (s) do not differ significantly (p=0.01) by DMRT.

Conclusion

Among the fungicides, Score 250 EC (Difenoconazole) was found most effective followed by Rovral 50 WP (Ipridione) against purple blotch complex of onion. At 99 DAP, these two fungicides reduced leaf incidence (71.23% and 70.63%) and leaf severity (80.53% and 79.21%) respectively over control. Similarly they reduced floral stalk incidence (81.67% and 79.95%) and stalk severity (81.94% and 80.99%) respectively over control at 136 DAP. Among the botanicals, alamanda leaf extract gave best result followed by neem leaf extract. At 99 DAP, 22.75% leaf incidence reduced by alamanda leaf extract over control. However, 46.96% and 33.65% leaf severity were decreased over control for alamanda leaf extract and neem leaf extract. Alamanda leaf extract reduced 19.31% floral stalk infection over control at 136 DAPS. Whereas, disease severity in floral stalk were reduced 34.82% and 30.48% for Alamanda and Neem, respectively at 136 DAP over control. At 99 DAP, 17.19%, 10.05% and 6.40% leaf incidence reduced for poultry waste, bioagent and micronutrient, respectively over control. In case of disease severity, poultry waste showed better performance followed by bioagent and micronutrient. In terms of yield it was counted that seed yield increased by 134.38%, 128.91%, 99.6 %, 72.27%, 58.20% and 69.53% for Score 250 EC, Rovral 50 WP and allamanda leaf extract, soil amendment by poultry waste; bioagent and micronutrient, respectively over control. Based on the performances of the treatments assayed in this experiment, Score250 EC (O.05%) as bulb treatment and foliar spraying at 10 days

intervals will be suited for the management of the purple blotch complex of onion for seed production. In addition, for best performance, soil amendment by poultry waste will be helpful for better seed yield.

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