INTEGRATION OF SELECTED IDM COMPONENTS FOR THE MANAGEMENT OF PURPLE BLOTCH COMPLEX DISEASE OF ONION IN BANGLADESH

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ABSTRACT

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An investigation was conducted in the central farm of Sher-e-Bangla Agricultural University to formulate an integrated approach for the management of purple blotch complex of onion for seed production. Among the 16 treatment combinations, bulb treatment + foliar spraying with Score 250 EC + soil amendment by poultry waste and bulb treatment + foliar spraying with Rovral 50 WP + soil amendment by poultry waste performed better in reducing the incidence and severity of purple blotch complex of onion and boosting up the seed yield to 708.30 kg/ha and 705.00 kg/ha i.e. 229.30% and 227.91%, with Benefit Cost Ratio (BCR) 9.60 and 9.56, respectively. Integration of either Score 250 EC (O.5%) or Rovral 50 WP (0.2%) as bulb treatment and foliar spraying at 7 days' intervals in combination with soil amendment by poultry waste found to be suited and cost effective approach.

Key Words: IDM components, purple blotch complex, onion, BCR

INTRODUCTION

Onion is one of the well-known and important spice crops grown all over the world including Bangladesh and stands second in terms of annual world production out of 15 important spice crops listed by FAO (Anon. 2012). The onion suffers from different diseases are mostly caused by the fungi and these are purple blotch, seed rot, germination reduction, black mould, germination failure and white blotch or *Stemphylium* blight. Among the diseases, purple blotch of onion caused by *Alternaria porri* and white blotch of onion caused by *Stemphylium vesicarium* are considered as the most damaging diseases (Fakir 2002). Most of the time, these two diseases simultaneously attack the onion crop and make a complex form of disease which is popularly known as purple blotch complex of onion (Islam *et al.* 2001). *A. porri* and *S. vesicarium* are both potentially important pathogens in winter-grown *Allium* crops and purple leaf blotch symptoms were considered to be a complex caused by both pathogens (Suheri and Price 2000). This disease is become most devastating by reducing both bulb yield and seed production all over the world including Bangladesh (Rashid and Haque 2015; Mishra and Gupta 2012).

Purple blotch complex of onion produces small, sunken, elongate and whitish lesion with a purple center. As lesions enlarge, they become zonate-brown to purple, surrounded by a yellow zone and extend upward and downward for some distance. Later concentric light and dark zones appear in the affected area. Under humid condition, the blotches become covered with black fruiting bodies (spores). A few large lesions have been formed in a leaf or seed stalk which may coalesce and girdle the leaf or seed stalks and tissues, distal to the lesions die. Usually the affected leaves or seed stalks break down and die within 4 weeks in the favorable environmental condition (Gupta *et al.* 1991). Bulbs can be infected at harvesting if the pathogen enters neck wounds. Storage symptoms appear as a dark yellow to wine-red spongy rot of outer and inner scales of bulbs. In India about 20 to 25% losses in seed yield have been reported (Thind and Jhooty 1982) while in Bangladesh, it was reported as 41-44% (Fakir 2002). Purple blotch and Stemphylium blight are reported as the most common diseases in Northern India, where 80 to 85% disease incidence was reported that affect leaves and seed stalk of onion (Tomaz and Lima 1988). The fungus *A. porri (*Ellis) and *Stemphylium vesicarium* produce an injurious toxin zinnol, which affect seed germination and seedling growth (Ellis 1971).

The disease is currently managed by routine application of several fungicides (Mishra and Gupta 2012; Hosen *et al.* 2009). Most of the new generation pesticides are systemic in nature and leads to certain level of toxicity in the plant system and thus resulting health hazards. Further, it disturbs microbial diversity of whole ecosystem. Fertilizer management like use of poultry manure, ash, cow dung, mustard oil cake and NPK, Zn, S and B could be the options for the management of purple blotch of onion. As a tool of integrated pest management, attempts to be made to evaluate different eco-friendly components plant extracts, bioagents, argo-waste along with fungicides to manage the disease. Based on the above facts the present piece of research was undertaken to formulate an integrated approach for the management of purple blotch complex of onion for seed production.

MATERIALS AND METHODS

The field experiments were conducted at the farm of Sher-e-Bangla Agricultural University (SAU), Dhaka-1207. The soil of the experimental site belongs to the agro-ecological region of "Madhupur Tract" (AEZ No. 28). The experiment was conducted with Randomized Complete Block Design (RCBD) with 16 treatments and 4 replications maintaining plot size (2 x 1.5) m^2, block to block distance 1 m, plot to plot distance 1 m, row to row spacing 25 cm and plant to plant spacing 20 cm. Altogether 16 different treatments comprising the selected integrated disease management (IDM) components along with combinations were used in this experiment. The treatments wereT_0 = Control (Bulb treatment + foliar spraying with plain water);T_1 = Bulb treatment + Foliar spraying with Rovral 50 WP (0.2%);T_2 = Bulb treatment + Foliar spraying with Score 250 EC (0.1%);T_3 = Bulb treatment + Foliar spraying with Alamanda leaf extract @ 1:2 (w/v);T_4= Soil amendment with Trico-compost @ 5 t/ha;T_5 = Soil amendment by Poultry waste @ 5 t/ha;T_6 = Soil amendment by $ZnSO_4$ (Zn) @ 5 kg/ha and Borax (B) @ 5 kg/ha;T_7= T_1+T_4; T_8= T_1+T_5; T_9= T_1+T_6; T_{10}= T_2+T_4; T_{11}= T_2+T_5; T_{12}= T_2+T_6; T_{13}= T_3+T_4; T_{14}= T_3+T_5; and T_{15}= T_3+T_6.

The selected IDM components those were found promising through laboratory assay and field trial were integrated for their combined performance in controlling purple blotch complex of onion for seed production (Ara 2013). The popular and widely cultivated local variety of onion "Taherpuri" was used in this experiment. The botanical extracts and the fungicidal solutions were prepared by adding sterile water with required amount of fungicides (Ara 2013). Before plantation, the onion bulbs were treated with the respective solutions of plant extracts and fungicides by dipping the bulbs for 15 minutes. The treated bulbs were then shade dried and sown in the field without delay. For control treatment the bulbs were treated with plain water only. The inoculum was collected from Ara (2013) and inoculation was done with spore suspension of *A. porri* and *S. vesicarium* at 21 days after planting (DAP). Spraying of fungicides, plant extracts and tri-compost were started from 36 days after bulb planting and 10 sprayings were done at 7 days intervals with a hand sprayer. One liter of suspension of each fungicide and plant extract was used to spray the plants under each treatment. To avoid the drifting of the fungicides during application, temporary fencing was made with polyethylene sheet surrounding the unit plot. A control treatment was maintained in each block where spraying was done with plain water only. Bulbs of onion were planted on 10 November 2012. Irrigation, weeding and mulching were given as per requirement of the land with regular intervals.

Twelve plants were selected randomly for each unit plot and tagged for data collection. Data were collected at7 days' intervals starting from the onset of disease symptoms and continued up to crop maturity.

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 (leaf and stalk) was calculated using the formula of Wheleer (1969).

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

Leaf and stalk area diseased of the selected plants were measured and recorded by conversion in 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 percent leaf area diseased (LAD) and percent stalk area diseased (SAD) were calculated using the following formula:

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

The disease severity of purple blotch complex of onion was calculated as PDI (Percent Disease Index) using '0 - 5' scale of Harsfall and Barrett (1945) as stated by Ara (2013). Onion seeds were harvested when the umbel had been showing the sign of ripen and black seeds were seen from outside by umbels eruption. The weight of dried seeds for each unit plot was recorded separately. The numbers and diameter of umbel under each treatment were also recorded. Weight of 1000 seeds per plot under each treatment was recorded individually by digital balance (0.001 g). The seed yield per plot under each treatment was converted into kg/ha.

Data were analyzed statistically using MSTAT Computer Program. Percent data were transformed following Arcsine transformation. Means of treatment were separated using Duncan's Multiple Range Test (DMRT) as described by Gomez and Gomez (1983).

Costing of application of integrated approaches for management of purple blotch complex of onion was done based on current market price of input, rate of hiring laborer and agricultural machineries. Price of the field produce was determining on the basis of current market value. Estimation of Cost Benefit Ratio (BCR) was done according to Gittenger (1982) and Islam *et al.* (2004) using the following formula:

$$\text{Benefit Cost Ratio (BCR)} = \frac{\text{Gross return (Tk./ha)}}{\text{Total cost of production (Tk./ha)}}$$

RESULTS AND DISCUSSION

The efficacy of different treatment combinations in respect of disease incidence as well as disease severity and yield with different yield contributing characters were varied significantly.

Disease incidence (leaf): The disease incidence was recorded with 7 days' intervals starting from 36 DAP to 92 DAP. At 92 DAP, the foliar spraying of Score 250EC in combination with soil amended by poultry manure (T_{11}) performed better in suppressing leaf infection (76.90 %) followed by Rovral 50WP in combination with soil amended by poultry manure (T_8) that suppressed leaf infection by 74.97%. The highest leaf infection (99.88%) was observed in untreated control plot (Table 1). The infection was gradually increased with the age and was much slower in T_8 and T_{11} treated plot compared to other.

Disease Severity (leaf): The suppression of disease severity (PDI) by treatment T_{11} (Score 250 EC + poultry manure) and T_8 (Rovral 50 WP + poultry manure) found to be promising. At 92 DAP, the lowest PDI (12.09 %) was observed in treatment T_{11} which showed highest reduction (87.86 %) of disease severity over control followed by T_8, where 85.77 % reduction of disease severity was counted over control (Table 2). The disease severity was gradually increased with the age and was much slower in T_{11} and T_8 in comparison to other.

Disease incidence (stalk): Different treatments showed statistically significant variation in respect of percent stalk infection. At 136 DAP, the foliar spraying of Score 250 EC in combination with soil amended by poultry manure (T_{11}) performed better in suppressing stalk infection (80.74 %) followed by Rovral 50 WP in combination with soil amended by poultry manure (T_8) that suppressed leaf infection by 79.09%. The highest stalk infection (99.78%) was observed in untreated control plot (Table 3). The percent stalk infection was gradually increased with the age of the crop and increasing rate of infection was much slower in T_{11} and T_8 treated plot compared to other treatments.

Disease Severity (stalk): The effects of different integrated treatments on disease severity in terms of PDI of stalk differed significantly (Table 4). The suppression of disease severity was found to be promising by treatment T_{11} (Score 250 EC + poultry manure) and T_8 (Rovral 50 WP + poultry manure). At 136 DAP, the lowest PDI (8.57 %) was observed in treatment T_{11} which showed highest reduction (87.58%) of disease severity over control followed by T_8, where 87.42 % reduction of disease severity was counted over control**.** The disease severity was gradually increased with the age and was much slower in $T_{11}$and T_8 in comparison to other treatments.

Yield and yield contributing characters: Significantly different effects of various integrated treatments used for the formulation of integrated approach for the management of purple blotch complex of onion for seed production were observed on yield and yield contributing characters like height of seed stalk, number of seed stalk/hill, number of umbel/plot, umbel diameter (cm) and 1000-seed weight (g) and seed yield (kg/ha) of onion (Table 5).

Height of onion seed stalk (cm): The effect of different integrated treatments on height of seed stalk of onion differed among the treatments that ranged from 53.83 cm to 66.93 cm (Table 5). At full grown phase, the highest height of onion seed stalk was recorded under treatment T_{11} (66.93 cm) followed by T_8 (65.41 cm) and T_7 (65.21 cm). The lowest height of seed stalk was recorded in untreated control plot (53.83 cm). The treatments T_1, T_2, T_9, T_{10} and T_{14} were similar to the treatment T_7 in respect of stalk height.

Table 1. Effect of different integrated treatments on disease incidence (leaf) of purple blotch complex of onion in the field recorded at different days after planting (DAP)

Treatment	Percent disease incidence (leaf) at different days after planting (DAP)									
	36 DAP	43DAP	50DAP	57 DAP	64 DAP	71 DAP	78 DAP	85 DAP	92 DAP	% decrease of disease incidence over control at 92 DAP
T_0	20.56 a	28.43 a	40.61 a	48.15 a	57.12 a	74.33 a	81.15 a	92.63 a	99.88 a	
T_1	10.73 fg	17.04 g	19.83 ij	22.21 ij	24.75 ij	30.24 k	32.10 l	36.71 l	44.25 j	55.70
T_2	11.78 ef	18.25 e-g	21.86 h	25.11 gh	28.01gh	35.11 i	39.47 i	45.32 j	52.96 h	46.98
T_3	18.62 b	18.91e	26.98 e	30.39 de	33.89 de	37.57 h	41.07 h	47.15 i	58.99 ef	40.94
T_4	20.43 a	21.63 c	33.08 c	37.59 c	37.75 c	57.13 c	55.83 c	67.75 c	65.99 c	33.93
T_5	19.21 b	20.79 cd	30.51 d	33.01 d	33.43 de	53.67 d	53.47 d	61.94 d	64.72 cd	35.20
T_6	20.48 a	26.45 b	37.72 b	41.56 b	41.89 b	61.50 b	68.49 b	71.71 b	68.31 b	31.61
T_7	10.41 g	18.05 e-g	19.10 ij	21.93 ij	24.33 j	28.56 l	31.39 l	35.82 l	43.33 j	56.62
T_8	9.23 h	11.41 h	18.53 j	20.64 j	21.51 k	22.14 m	23.06 m	24.24 m	25.00 k	74.97
T_9	11.75 ef	17.42 fg	21.43 h	24.91 gh	27.56 g-i	33.01 j	37.90 j	39.81k	53.24 h	46.70
T_{10}	11.38 e-g	17.58 e-g	20.60 hi	23.61 hi	26.20 h-j	32.42 j	35.44 k	40.13 k	49.24 i	50.70
T_{11}	8.64 h	10.72 h	11.89 k	14.86 k	16.85 k	17.93 m	19.95 n	22.02 n	23.07 l	76.90
T_{12}	15.55 c	1.56 i	25.43 f	28.85 ef	31.92 ef	41.81 g	47.41 f	53.98 g	59.27 e	40.66
T_{13}	13.53 d	18.55 ef	24.40 fg	28.95 ef	30.43 fg	45.56 f	48.73 f	55.99 f	56.62 g	43.31
T_{14}	12.37 e	18.42 e-g	23.40 g	27.07 fg	28.84 gh	40.67 g	45.32 g	49.41 h	57.29 fg	42.64
T_{15}	19.12 b	20.25 d	27.75 e	32.56 d	35.81 cd	48.04 e	51.49 e	59.49 e	63.16 d	36.76
LSD (0.01)	1.12	1.23	1.50	2.56	2.78	1.56	1.32	1.69	1.81	
CV (%)	4.05%	3.57%	3.13%	4.68%	4.66%	1.99%	1.55%	1.75%	1.69%	

T_0=Control (using fresh water)
T_1= Rovral 50 WP
T_2 = Score 250 EC
T_3= Alamanda
T_4= Soil amendment with Trico-compost
T_5= Soil amendment with Poultry waste
T_6=Micronutrient (Zinc+Boran)
T_7= T_1+T_4 (Rovral + Trico-compost)
T_8= T_1+T_5 (Rovral + Poultry waste)
T_9= T_1+T_6 (Rovral + Micronutrient)
T_{10}= T_2+T_4 (Score 250 EC + Trico-compost)
T_{11}= T_2+T_5 (Score 250 EC + Poultry waste)
T_{12}= T_2+T_6 (Score 250 EC + Micronutrient)
T_{13}= T_3+T_4 (Alamanda + Trico-compost)
T_{14}= T_3+T_5 (Alamanda + Poultry waste)
T_{15}= T_3+T_6 (Alamanda + Micronutrient)

Valus in a coloum with same letter (s) do not differ significantly (p=0.01); bulb treatment and foliar spraying were done by each respective solution

Number of onion seed stalk/hill: Significant differences observed among the effect of different integrated treatments on number of seed stalk/hill and ranged from 1.08 cm to 2.43 cm (Table 5). The highest average number of seed stalk was observed in treatment T_{11} (2.43) which was statistically similar to treatment T_8 (2.43), T_7 (2.38), T_1 (2.34) and T_{10} (2.16). The lowest number of seed stalk/hill was recorded in untreated control plot T_0 (1.08) which was statistically similar to treatment T_6 (1.22).

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

Treatment	Percent disease index (PDI-leaf) at different days after planting (DAP)									
	36 DAP	43 DAP	50 DAP	57 DAP	64 DAP	71 DAP	78 DAP	85 DAP	92 DAP	% decrease of PDI over control at 92 DAP
T_0	11.60 a	14.52 a	28.76 a	31.78 a	45.91 a	58.44 a	58.44 a	90.57 a	99.61 a	
T_1	2.16 j	2.42 k	5.28 j	11.40 j	13.63 k	17.65 m	17.65 l	35.16 k	58.65 j	41.12
T_2	3.33 h	4.010 i	6.870 h	14.31gh	17.13 i	22.26 j	32.34 f	44.77 i	51.90 m	47.90
T_3	6.53 e	6.63 f	14.44 f	18.37 e	37.78 d	29.45 f	39.53 e	60.66 f	63.81 f	35.94
T_4	7.16 c	10.29 c	18.15 c	22.44 c	43.25 bc	49.17 c	49.17 c	79.10 c	92.24 c	7.40
T_5	6.90 cd	9.057 d	17.23 d	20.30 d	42.55 c	43.63 d	43.63 d	73.78 d	87.80 d	11.86
T_6	10.61b	11.62 b	21.44 b	24.40 b	43.53 b	53.70 b	53.70 b	81.91 b	94.28 b	5.35
T_7	1.40 k	1.94 l	5.16 j	10.29 k	12.35 l	16.35 n	16.35 m	33.50 l	55.63 l	44.15
T_8	0.65 l	1.63 lm	4.33 k	4.58 l	5.40 m	6.94 o	8.54 n	12.65 m	14.17 n	85.77
T_9	3.02 i	3.15 j	6.13 i	13.91h	15.23 j	20.30 k	20.30 j	42.42 j	61.98 gh	37.78
T_{10}	3.00 i	2.64 k	5.93 i	12.60 i	14.32 jk	18.91 l	18.91 k	35.56 k	60.56 i	39.20
T_{11}	0.06 m	1.32 m	2.53 l	3.34 l	4.14 n	7.26 o	8.27 n	10.20 n	12.09 o	87.86
T_{12}	5.76 f	6.09 g	9.09 g	17.27 f	31.43 f	27.35 g	27.35 g	57.74 g	57.32 k	42.46
T_{13}	6.03 f	6.02 g	8.58 g	16.33 f	28.54 g	25.62 h	25.62 h	53.99 h	61.56 hi	38.20
T_{14}	5.17 g	4.41 h	7.38 h	15.12 g	25.70 h	24.18 i	24.18 i	5.622 o	62.97 fg	36.78
T_{15}	6.78 de	7.99 e	16.23 e	18.66 e	34.51 e	31.74 e	31.74 f	63.69 e	69.04 e	30.69
LSD (0.01)	0.27	0.32	0.53	1.07	0.93	0.62	0.62	1.03	1.19	
CV (%)	2.88%	2.89%	2.52%	3.48%	1.86%	1.13%	1.08%	1.09%	0.97%	

T_0=Control (using fresh water)
T_1= Rovral 50 WP
T_2 = Score 250 EC
T_3= Alamanda
T_4= Soil amendment with Trico-compost
T_5= Soil amendment with Poultry waste
T_6=Micronutrient (Zinc+Boran)
T_7= T_1+T_4 (Rovral + Trico-compost)
T_8= T_1+T_5 (Rovral + Poultry waste)
T_9= T_1+T_6 (Rovral + Micronutrient)
T_{10}= T_2+T_4 (Score 250 EC + Trico-compost)
T_{11}= T_2+T_5 (Score 250 EC + Poultry waste)
T_{12}= T_2+T_6 (Score 250 EC + Micronutrient)
T_{13}= T_3+T_4 (Alamanda + Trico-compost)
T_{14}= T_3+T_5 (Alameda + Poultry waste)
T_{15}= T_3+T_6 (Alamanda + Micronutrient)

Valus in a coloum with same letter (s) do not differ significantly (p=0.01); bulb treatment and foliar spraying were done by each respective solution

Number of umbel/plot: The effect of different integrated treatments varied in respect of number of umbel/plot (Table 5). The highest number of umbel/plot (142.50) was recorded under treatment T_{11} which was statistically similar to treatment T_8 (142.30), T_7 (140.50) and T_1 (138.50). The lowest number of umbel/plot was recorded in untreated control treatment T_0 (66.00).

Umbel diameter (cm): Significant differences were observed among the umbel diameter in response to different integrated treatments which ranged from 5.37 cm to 6.32 cm (Table 5). The highest umbel diameter (6.32 cm) was noted under treatment T_{11} which was statistically similar to treatment T_8 (6.31cm), T_7 (6.31), T_{10} (6.29), T_1 (6.29) and T_9 (6.27). The lowest umbel diameter was found in control treatment T_0 (5.37 cm).

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

Treatment	Percentinfected 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 DI over control at 136 DAP
T_0	6.528 a	27.20 a	35.80 a	51.57 a	57.27 a	69.98 a	84.14 a	98.60 a	99.78 a	
T_1	5.24 de	14.31 j	14.79 l	18.93 m	22.48 m	37.64 m	50.49 l	58.79 m	60.56 l	39.31
T_2	5.33 de	18.44 g	20.30 i	26.74 j	32.83 j	47.57 j	61.97 i	70.40 j	65.41 i	34.45
T_3	5.49 c-e	24.38 d	27.46 e	35.57 f	43.54 f	58.40 f	72.69 e	81.93 f	75.68 e	24.15
T_4	6.06 a-c	26.58 b	33.53 b	44.62 c	52.92 c	65.64 c	84.54 a	90.95 c	78.62 c	21.21
T_5	5.85 b-d	25.31 c	31.76 c	41.70 d	50.49 d	63.44 d	80.72 c	86.85 d	76.60 d	23.23
T_6	6.45 ab	27.18 a	35.77 a	50.99 b	56.56 b	69.24 b	83.04 b	97.49 b	99.08 b	0.70
T_7	5.22 de	12.90 k	14.71 lm	18.24 n	22.22 m	36.46 n	49.48 m	56.20 n	58.58 m	41.29
T_8	5.16 de	7.68 m	10.42 n	12.66 p	13.36 n	15.00 p	16.85 n	19.00 p	20.86 o	79.09
T_9	5.44 c-e	17.93 h	18.69 j	23.19 k	28.51 k	43.28 k	59.76 j	67.32 k	64.71 j	35.15
T_{10}	5.32 de	15.23 i	16.84 k	21.67 l	26.71 l	40.87 l	54.04 k	62.75 l	63.90 k	35.96
T_{11}	5.08 e	7.355 m	8.180 n	10.15 p	13.61 n	14.57 p	16.43 n	18.64 p	19.22 o	80.74
T_{12}	5.39 de	23.32 e	25.41 f	32.76 g	41.46 g	55.13 g	69.67 f	80.33 g	71.65 f	28.19
T_{13}	5.35 de	20.15 f	24.70 g	30.44 h	38.59 h	52.35 h	66.75 g	76.77 h	69.58 g	30.27
T_{14}	5.33 de	20.04 f	22.31 h	28.46 i	35.79 i	50.42 i	64.61 h	72.87 i	68.32 h	31.53
T_{15}	5.63 c-e	12.68 l	14.42 m	17.66 o	22.06 m	35.33 o	48.85 m	32.49 o	56.66 n	43.22
LSD (0.01)	0.60	0.23	0.36	0.45	0.50	0.51	0.65	0.66	0.67	
CV (%)	0.18%	0.59%	0.80%	0.78%	0.71%	0.53%	0.53%	0.49%	0.51%	

T_0=Control (using fresh water)	T_4= Soil amendment with Trico-compost	T_8= T_1+T_5 (Rovral + Poultry waste)	T_{12}= T_2+T_6 (Score 250 EC + Micronutrient)
T_1= Rovral 50 WP	T_5= Soil amendment with Poultry waste	T_9= T_1+T_6 (Rovral + Micronutrient)	T_{13}= T_3+T_4 (Alamanda + Trico-compost)
T_2 = Score 250 EC	T_6=Micronutrient (Zinc+Boran)	T_{10}= T_2+T_4 (Score 250 EC + Trico-compost)	T_{14}= T_3+T_5 (Alamanda + Poultry waste)
T_3= Alamanda	T_7= T_1+T_4 (Rovral + Trico-compost)	T_{11}= T_2+T_5 (Score 250 EC + Poultry waste)	T_{15}= T_3+T_6 (Alameda + Micronutrient)

Valus in a coloum with same letter (s) do not differ significantly (p=0.01); bulb treatment and foliar spraying were done by each respective solution

Thousand seed weight (g): Differences were observed among the integrated treatments on 1000 seed weight (Table 5). The highest 1000 seed weight (3.55 g) of onion was recorded under treatment T_{11}, T_8 and T_{10} which was statistically similar to treatment T_7 (3.53 g), T_9 (3.51 g), T_1 (3.51 g) and T_2 (3.48 g). The lowest 1000 seed weight was noted in control treatment T_0 (2.91 g).

Seed yield (kg/ha): The performances of various integrated treatments differed significantly in respect of seed yield of onion (Table 5). The highest onion seed yield (708.30 kg/ha) was recorded under treatment T_{11} which was statistically similar to treatment T_8(705.00 kg/ha) followed by T_{10} (661.80 kg/ha) and T_7 (609.80 kg/ha). The lowest seed yield was recorded in control treatment T_0 (214.50 kg/ha). The highest percent of increase of seed yield over control was recorded in treatment T_{11} (229.30%) followed by T_8(227.91%). The lowest percent of increase of onion seed yield over control was recorded in treatment T_6 (87.91%).

Benefit Cost Ratio (BCR) analysis: The Benefit Cost Ratio (BCR) of the applied integrated treatments for the management of purple blotch complex of onion was estimated (Gittenger 1982 and Islam *et al.* 2004). Estimation showed that treatment T_{11} that combined soil amendment with poultry waste followed by bulb treatment and foliar spraying with fungicide Score 250 EC yielded the highest return (BCR=9.60) where Tk. 9.60 could be earned by investing Tk. 1.00 (Table 6). The BCR 9.56 was estimated in treatment T_8 that combined soil amendment with poultry waste followed by bulb treatment and foliar spraying with fungicide Rovral 50 WP. Among the rest of the treatments T_{10} (BCR-9.24), T_7 (BCR-8.51), T_9 (BCR-7.85), T_{12} (BCR-7.57), T_2 (BCR-7.41), T_1 (BCR-7.31) and T_{13} (BCR-7.23) revealed to be promising in respect of economic return.

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

Treatment	Percent disease index(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	3.61 a	5.72 a	8.39 a	20.26 a	22.64 a	32.67 a	48.72 a	53.77 a	69.01 a	
T_1	1.97 d-f	2.16 m	2.53 i	3.64 l	3.96 m	5.338 l	6.943 m	7.387 m	18.64 l	72.99
T_2	2.20 d-f	3.21 j	3.34 f	4.60 j	7.53 j	9.597 i	11.59 j	14.59 j	25.57 i	62.95
T_3	2.53 b-d	4.36 f	3.62 e	13.60 f	14.31 f	18.17 e	20.44 f	25.23 f	42.90 e	37.84
T_4	3.35 a	5.43 c	6.81 c	17.32 c	19.05 c	24.25 c	30.74 c	48.74 c	59.54 c	13.72
T_5	3.12 ab	5.16 d	5.96 d	16.47 d	17.63 d	20.61 d	29.13 d	35.48 d	52.90 d	23.34
T_6	3.62 a	5.63 b	8.23 b	19.90 b	22.28 b	30.07 b	42.63 b	51.58 b	67.61 b	2.03
T_7	1.80 d-f	2.01 n	2.43 j	3.63 l	4.00 m	5.32 l	6.77 mn	7.35 m	18.14 l	73.71
T_8	1.69 ef	1.94 o	2.23 k	3.37 lm	3.27 n	5.14 l	6.42 n	7.34 m	8.68 n	87.42
T_9	2.07 d-f	3.07 k	2.95 g	4.16 k	6.19 k	8.27 j	10.40 k	11.58 k	23.90 j	65.37
T_{10}	2.06 d-f	2.82 l	2.77 h	3.92 k	5.01 l	7.01 k	9.02 l	9.16 l	20.68 k	70.03
T_{11}	1.53 f	1.87 p	1.99 l	3.14 m	3.10 n	5.13 l	6.27 n	7.23 m	8.57 n	87.58
T_{12}	2.40 b-e	4.18 g	3.61 e	10.18 g	12.32 g	16.58 f	18.34 g	21.50 g	14.34 m	79.22
T_{13}	2.31 c-e	3.95 h	3.64 e	9.217 h	10.31 h	13.75 g	15.24 h	19.64 h	38.54 f	44.15
T_{14}	2.33 c-de	3.58 i	3.64 e	6.943 i	9.217 i	11.19 h	13.23 i	16.97 i	35.57 g	48.46
T_{15}	3.00 a-c	4.82 e	3.62 e	15.28 e	14.60 e	18.40 e	23.99 e	30.36 e	29.01 h	57.96
LSD (0.01)	0.67	0.06	0.06	0.26	0.24	0.26	0.48	0.49	0.70	
CV (%)	0.52%	0.79%	0.81%	1.45%	1.19%	0.98%	1.35%	1.13%	1.08%	

T_0=Control (using fresh water)
T_1= Rovral 50 WP
T_2 = Score 250 EC
T_3= Alamanda
T_4= Soil amendment with Trico-compost
T_5= Soil amendment with Poultry waste
T_6=Micronutrient (Zinc+Boran)
T_7= T_1+T_4 (Rovral + Trico-compost)
T_8= T_1+T_5 (Rovral + Poultry waste)
T_9= T_1+T_6 (Rovral + Micronutrient)
T_{10}= T_2+T_4 (Score 250 EC + Trico-compost)
T_{11}= T_2+T_5 (Score 250 EC + Poultry waste)
T_{12}= T_2+T_6 (Score 250 EC + Micronutrient)
T_{13}= T_3+T_4 (Alamanda + Trico-compost)
T_{14}= T_3+T_5 (Alameda + Poultry waste)
T_{15}= T_3+T_6 (Alamanda + Micronutrient)

Valus in a coloum with same letter (s) do not differ significantly (p=0.01); bulb treatment and foliar spraying were done by each respective solution

Among 16 treatment combinations the treatment T_{11} and T_8 showed the better performance in reducing the incidence and severity of purple blotch complex of onion with increasing the seed yield and yield contributing characters where Score 250 EC or Rovral 50 WP was applied as bulb treatment followed by foliar spraying with corresponding fungicide that integrated with soil amendment by poultry waste. At 92 DAP, while the leaf infection was 99.88% in control, the leaf infection was 23.07% and 25,00%, respectively for application of either Score 250EC or Rovral 50 WP integrated with soil amendment by poultry waste that decrease the leaf incidence by 76.90% and 74.97%, respectively. Similarly, while the stalk incidence in control was 99.78% then it was 19.22% and 20.86%, respectively for application of Score 250 EC or Rovral 50 WP integrated with soil amendment by poultry waste that reduced the stalk incidence by 80.74% and 79.09%, respectively.

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

Treatment	Height of Stalk(cm)	No. of Stalk/hill	No. of Umbel/plot	Umbel diameter (cm)	1000 Seed weight (g)	Seed yield (kg/ha)	% Increase of seed yield over control
T_0	53.83 l	1.08 i	66.00 i	5.37 i	2.91 f	214.50 j	
T_1	64.97 c	2.34 ab	138.50 a	6.29 ab	3.51 a	519.5 0f	141.86
T_2	64.17 e	2.01 cd	116.80 cd	6.24 b-d	3.48 a	527.00 ef	145.12
T_3	58.89 h	1.72 ef	100.50 e	6.20d	3.34 c	443.80 h	106.51
T_4	54.51 j	1.42 gh	83.75 g	5.95 g	3.24 d	433.00 h	101.40
T_5	54.26 k	1.56 fg	93.00 f	6.04 f	3.25 d	483.00 g	124.65
T_6	54.07 k	1.22 hi	71.25 h	5.45 h	3.00 e	404.00 i	87.91
T_7	65.21 b	2.38 a	140.50 a	6.31 a	3.53 a	609.80 c	183.72
T_8	65.41 b	2.43 a	142.30 a	6.31 a	3.55 a	705.00 a	227.91
T_9	64.58 d	2.01 cd	119.00 c	6.27 a-c	3.51 a	560.00 d	160.47
T_{10}	64.66 d	2.16 bc	126.80 b	6.29 ab	3.55 a	661.80 b	207.91
T_{11}	66.93 a	2.43 a	142.50 a	6.32 a	3.55 a	708.30 a	229.30
T_{12}	63.60 g	1.76 ef	103.00 e	6.21 cd	3.33 c	540.30 e	151.16
T_{13}	63.93 f	1.93 de	113.50 d	6.20 d	3.41 b	520.00 f	141.86
T_{14}	64.08 ef	2.01 cd	118.30 c	6.21 cd	3.35 bc	214.50 j	139.07
T_{15}	57.90 i	1.66 f	99.00 e	6.13 e	3.33 c	519.50 f	109.30
LSD (0.01)	0.21	0.21	3.95	0.06	0.06	16.67	
CV (%)	0.18%	0.49%	1.87%	0.13%	0.14%	1.69%	

T_0=Control (using fresh water)
T_1= Rovral 50 WP
T_2 = Score 250 EC
T_3= Alamanda
T_4= Soil amendment with Trico-compost
T_5= Soil amendment with Poultry waste
T_6=Micronutrient (Zinc+Boran)
T_7= T_1+T_4 (Rovral + Trico-compost)
T_8= T_1+T_5 (Rovral + Poultry waste)
T_9= T_1+T_6 (Rovral + Micronutrient)
T_{10}= T_2+T_4 (Score 250 EC + Trico-compost)
T_{11}= T_2+T_5 (Score 250 EC + Poultry waste)
T_{12}= T_2+T_6 (Score 250 EC + Micronutrient)
T_{13}= T_3+T_4 (Alamanda + Trico-compost)
T_{14}= T_3+T_5 (Alamanda + Poultry waste)
T_{15}= T_3+T_6 (Alamanda + Micronutrient)

Valus in a coloum with same letter (s) do not differ significantly (p=0.01); bulb treatment and foliar spraying were done by each respective solution

Table 6. Benefit Cost Ratio (BCR) of different integrated management practices against purple blotch complex of onion for seed production

Treatments	Yield (kg/ha)	Gross income (Tk)	Total cost of production	Net Return (Tk.)	BCR
T_0	215	215000	68963 (a)	146037.00	3.12
T_1	520	520000	71183.30(a+b+h)	448816.70	7.31
T_2	527	527000	71164.04(a+c+h)	455835.96	7.41
T_3	444	444000	71442.95(a+d+h)	372557.05	6.21
T_4	433	433000	69713.00(a+e)	363287.00	6.21
T_5	483	483000	71813.00(a+f)	488187.00	6.73
T_6	404	404000	69413.60(a+g)	592586.40	5.82
T_7	610	610000	71663.30(a+b+h+e)	636336.70	8.51
T_8	705	705000	73763.30 (a+b+h+f)	466236.70	9.56
T_9	560	560000	71363.90(a+b+h+g)	448636.10	7.85
T_{10}	662	662000	71644.04(a+c+h+e)	442355.96	9.24
T_{11}	708	708000	73744.04(a+c+h+f)	376255.96	9.60
T_{12}	540	540000	71344.64(a+c+h+g)	143655.36	7.57
T_{13}	520	520000	71922.95(a+d+h+e)	448077.05	7.23
T_{14}	514	514000	74022.95(a+d+h+f)	452977.05	6.94
T_{15}	450	450000	71623.55(a+d+h+g)	372376.45	6.28

Price of onion seed @ Tk. 1000,000 per ton (2012)

T_0=Control (using fresh water)
T_1= Rovral 50 WP
T_2 = Score 250 EC
T_3= Alamanda
T_4= Soil amendment with Trico-compost
T_5= Soil amendment with Poultry waste
T_6=Micronutrient (Zinc+Boran)
T_7= T_1+T_4 (Rovral + Trico-compost)
T_8= T_1+T_5 (Rovral + Poultry waste)
T_9= T_1+T_6 (Rovral + Micronutrient)
T_{10}= T_2+T_4 (Score 250 EC + Trico-compost)
T_{11}= T_2+T_5 (Score 250 EC + Poultry waste)
T_{12}= T_2+T_6 (Score 250 EC + Micronutrient)
T_{13}= T_3+T_4 (Alamanda + Trico-compost)
T_{14}= T_3+T_5 (Alameda + Poultry waste)
T_{15}= T_3+T_6 (Alamanda + Micronutrient)

Bulb treatment and foliar spraying were done by each respective solution.

Here, a= Total cost of common cultural practices;b= Total cost of application of Rovral 50 WP; c= Total cost of application of Score 250 EC; d= Total cost of application of Alamanda; e= Total cost of application of Trico-compost; f= Total cost of application of Poultry waste; g= Total cost of application of Micronutrient;h= Total cost of application of Sprayer hired;

In case of disease severity, the PDI (leaf) in control plot at 92 DAP was 99.61% then it was 12.09% and 14.17%, respectively for the integration of Score 250 EC with poultry waste and Rovral 50WP with poultry waste and these two combinations reduced disease severity by 87.86% and 85.77%, respectively. Similarly, the PDI (stalk) at 92 DAP in control was 69.01% while it was 8.57% and 8.68%, respectively for the application of Score 250 EC with poultry waste and Rovral 50WP with poultry waste. The application of Score 250 EC or Rovral 50WP in combination with poultry waste as amendment also showed significant effect on yield and yield contributing characters of onion against purple blotch complex of onion. Significantly the highest performances on plant height, number of stalk, number of umbel, umbel diameter, 1000 seed weight and seed yield noted down due to the application of Score 250EC or Rovral 50 WP as bulb treatment followed by field spraying with corresponding fungicides integrated with soil amendment by poultry waste. Seed yield was tremendously increased owing to the application of these two combinations. Seed yield was 708.30 kg/ha in case of Score 250EC combined with soil amendment by poultry waste that increased yield by 229.30% over control. Besides, seed yield was 705.00 kg/ha in case of Rovral 50WP combined with soil amendment by poultry waste that increased yield by 227.91% over control. Rashid and Haque (2015) reported that the lowest incidence and severity of purple blotch disease were observed in case of seedling dipping + Rovral 50 WP + poultry manure + spray at 7days' interval. The highest incidence and severity of the disease were recorded in control treatment. On the basis of the findings they concluded that the onion growers may be suggested for applying Rovral 50 WP (0.2%) along with Poultry manure in controlling purple blotch of onion for bulb production. Similar result was found by Hafiz (2009) who reported that soil application of poultry manure combined with seedling dipped in Rovral 50 WP followed by foliar spraying with Rovral 50WP effectively control the purple blotch disease and increasing yield by 363.22% over control.

Among the rest of the integrated treatment combination of trico-compost with Score 250 EC or Rovral 50WP and combination of micronutrient with either Score 250EC or Rovral 50 WP also seemed to be potential against purple blotch of onion. Soil application of *Trichderma* based compost combined with application of Score 250 EC or Rovral 50WP applied as bulb treatment as well as foliar spraying resulted 207.91% and 183.72% yield increased respectively over control. Application of micronutrient (Zinc + Boron) applied as basal dose in combination with application of Score 250 EC or Rovral 50WP as bulb treatment and foliar spraying resulted 160.47% and 151.16% yield increased respectively over control. The present findings of the experiment were well supported by the reports of previous workers (Hafiz 2009; Ali 2008; Hossain 2008; Khatun 2007; Ahmed 2007; Nahar*et al.* 2006; Islam *et al.* 2001; Hossain 2008; Islam 1995). Ali (2008) reported that foliar spraying of Rovral in combination with micronutrient ($ZnSO_4$+Borax) drastically reduced the purple blotch disease severity and thereby increasing the bulb yield of onion. Ahmed (2007) reported that spraying of *Trichoderma* spore followed by baking soda spray against purple blotch increased 67.63% yield of onion. Khatun (2007) reported that Rovral 50WP (0.2%) minimized the incidence and severity of purple blotch complex disease and increased bulb yield of onion. Nahar *et al.* (2006) used poultry manure in combination with Iprodione (Rovral 50WP) against purple blotch and obtained good harvest. Hossain (2008) reported that application of micronutrient (Zinc + Boron) increased considerable seed yield against purple blotch of onion in field condition. He also reported that foliar application of Rovral 50WP (0.2%) + Ridomil Gold (0.2%) in combination with Zinc + Boron, remarkably reduced disease severity and increasing seed yield. Islam (1995) reported that foliar spraying of Score 250 EC effectively controled purple blotch of onion with increasing bulb yield followed by foliar spraying of Rovral 50WP. Antagonistic effect of *Trichoderma* spp. and poultry waste against other plant pathogens was also reported by several researchers (Hasnat 2011; Bhuiya 2010; Meah *et al.*2004). Different strains of *Trichoderma harzianum* act as strong competitors to other plant pathogenic microorganisms in the rhizosphere (Harman *et al.*, 1989). The account of disease reduction by *Trichoderma* spp. was explained as the competition for space and nutrients with the pathogenic fungi (Alabouvette and Cauteaudier 1992) and the production of antibiotics by the antagonists (Larkin *et al.* 1996).

Integration of either Score250 EC (O.05%) or Rovral 50 WP (0.2%) as bulb treatment and foliar spraying at 7 days' intervals in combination with soil amendment by poultry waste found to be suited and cost effective approach for the management of the purple blotch complex of onion for seed production. The BCR of application of Score 250EC or Rovral 50WP for bulb treatment followed by foliar spraying in combination with soil amendment by poultry waste were 9.60 and 9.56, respectively while the BCR of control was 3.12 and thus the farmers could earn Tk. 6.48 or Tk. 6.44, respectively by investing Tk. 1.00 in comparison to control. Therefore, this integrated approach may be recommended to the onion growers for management of purple blotch complex of onion for seed production.

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