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Integrated disease management (IDM) strategies to check the late blight (*Phytophthora infestans*) disease apart from boosting the yield of potato crop

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Abstract
Late blight caused by the fungus *Phytophthora infestans* is the most important disease of potato that can result in crop failure within a short period, if appropriate control measures are not adopted. Despite the introduction of chemical, biological and host resistance strategies over years for controlling the disease, severe losses still occur largely because the effectiveness of these approaches is variable and often short lived. So, the present study was taken up by integrating or combining these strategies to control the disease. The different management components *viz*., tuber dressing with Dimethomorph, soil amendment with *Trichoderma Viride* and FYM, and foliar application of SAR chemical benzothiadiazole (BTH) and fungicides Dimethomorph 50WP and Mancozeb75WP alone as well as in alternation with each other were integrated and evaluated on two different varieties of potato i.e susceptible cultivar Kufri Jyoti as well as on a moderately resistant variety Shalimar-1 planted at two different locations in Kashmir *viz* Shalimar and Yarikha separately during 2017 cropping season. The results revealed that all the treatments proved effective in reducing the late blight incidence and intensity in comparison to control. The treatment with foliar application with either dimethomorph 50 WP or mancozeb 75 WP alone or in alternation with each other +foliar spray of BTH+ soil amendment (FYM+ T.viride) exhibited least blight incidence, intensity and A value (AUDPC) with concomitant higher yield gains and improvement in tuber grades followed by treatments which received foliar application of BTH +soil amendment (FYM + *T. Viride*) or soil amendment alone, whereas highest disease intensity, incidence and A value (AUDPC)with lowest yield and inferior grade tubers were observed in case of untreated control. Moderately resistant variety Shalimar 1 exhibited very less disease intensity, incidence and 'A'value compared to susceptible cultivar kufri jyothi when provided with similar treatments at both locations i.e Shalimar and Yarikha in Kashmir.

Keywords: Late blight of potato, fungicides, SAR inducer, soil amendment, resistant variety, disease intensity, tuber yield

Introduction
Potato late blight, caused by the Oomycete pathogen *Phytophthora infestans*, is the most notorious plant disease known, largely due to the epidemic that swept across Europe in 1845–46, leading to famine and mass emigration in Ireland. Late blight has subsequently spread worldwide and occurs in almost all regions where potatoes are grown, causing losses for large- and small-scale growers alike. The monetary costs of such losses combined with measures to control the disease have been estimated at more than $3 billion/year worldwide. The pathogen produces water soaked lesions with chlorotic borders that are small at first but expand rapidly under humid conditions, blighting the entire plant in only a few days with subsequent rotting of the developing tubers resulting in heavy yield losses under favourable conditions each year with reduction in global production by approximately 15 per cent. Losses of up to 10 to 75 per cent by the disease have been reported in India. The losses mainly depend on the crop growth stage at which the disease first appears and the severity being maximum in humid and high rainfall areas. The disease occurs annually in the cooler Himalayan regions extending from Assam to Kashmir at an altitude of 6,000 ft. or more as the crop is grown in the rainy season (Peerzada *et al*., 2020) [10].
Several strategies for controlling the disease have been introduced over years such as chemical control, biological control and host resistance etc. Host resistance strategies primarily include resistance varieties and are being cultivated over larger areas throughout globe, but severe losses still occur, largely because the effectiveness of these approaches is variable and often short lived. Also evolution of new pathotypes and races at faster frequency necessitate availability of alternate measures of late blight control to at least reduce selection pressure on the pathogen while at the same time keeping the disease at low ebb.

The current thinking about plant protection and environment suggests to develop such strategies that are effective, efficient and economical and that minimize the adverse effects on environment and human health. So, our present study was primarily focused upon the identification and logical integration of strategies that would contribute towards suppression of the pathogen and/or enhancing the host resistance at the same time reducing the harmful impact on environment due to excessive use of chemicals which are likely to be useful in managing the potato late blight by integrating various components of disease management.

Material and Methods

An assortment of identified disease management components such as crop variety, tuber treatment, soil amendments and foliar sprays, was assessed by laying out field trials at two locations-one at the University Main Campus Shalimar, Srinagar located at an altitude of 1730 feet above sea level and another at Potato Seed Multiplication Farm, Division of Vegetable Science (Yarikha) at an altitude of 2690 ft. above sea level in randomized block design with three replications, each plot consisting of 5 rows at an inter-row distance of 40 cm planted with 20 potato tubers, each maintaining a spacing of 20 cm. All the plots received recommended dose of fertilizers (80 kg N, 40 kg P_2O_5 and 25 kg K_2O). The planting was done on 30th march 2017 at the University farm, shalimar and on 20th April 2017 at Yarikha Farm using susceptible cultivar Kufri Jyoti and moderately resistant variety Shalimar-1 separately at both the locations. The potato tubers for the experiment were obtained from disease-free seed lots from the Division of Vegetable Science, SKUAST-K, Shalimar and treated with Dimethomorph 50 WP @ 2g/kg of tuber. The FYM and *Trichoderma viride* were mixed 48 hours before being applied as soil amendment treatment to plots and rotovator tilled into soil at a depth of about 15 cm. The SAR chemical BTH (benzothiadiazole) and fungicides *viz*. Mancozeb 75WP and dimethomorph 50WP were evaluated for their effectiveness under diverse agro ecological conditions. The foliar application of SAR chemicals commenced with the first appearance of late blight symptoms, followed by fungicidal sprays at weekly (for mancozeb 70 WP) and/or 10 days intervals (for dimethomorph 50 WP). Both susceptible and moderately resistant varieties were assessed for disease development. All other practices for raising the crop were followed according to recommended package of practices (Anonymous, 2004). Data recorded on late blight intensity was used to compute area under disease progress curve "AUDPC". Tubers were dug out at maturity when all the vines were dead; the yield data was recorded from individual plots and converted into qtls/ha, and the tubers categorized into different grades depending on tuber diameter.

Tuber diameter (cm)	Tuber grade
8 cm and above	A
4cm to 8cm	B
4 cm and below	C

The per cent yield increase (PYI) was calculated as

$$PYI = \frac{\text{Tuber yield obtained with Fungicide treatment} - \text{Tuber yield obtained in control plots}}{\text{Tuber yield obtained in control}} \times 100$$

Disease intensity: an area of 1m x 1.5m was randomly marked at 10 different places in the field and the observation on the extent of the foliage blighted was recorded until 10 days before dehaulming using the disease rating scale given by Mohan and Thind (1999) [9].

Disease Score	Score description in terms of foliage infected (%)
0	No visible symptoms
1	1-10
2	11-25
3	26-50
4	51-75
5	>75

The disease intensity was calculated by using the following formula

$$\text{Late blight intensity (\%)} = \frac{\text{Summation of numerical rating}}{\text{No. of plants Examined} \times \text{Maximum disease score}} \times 100$$

Per cent disease intensity recorded was transformed using arc sine transformation and subjected to analysis of variance (ANOVA) as suggested by Gomez and Gomez (1984).

Disease incidence: An area of 1 m x 1.5 m was randomly marked at 10 different places in the field for recording the total number of diseased and healthy plants until 10 days before dehaulming of the crop. Mathematically,

$$\text{Late blight incidence (\%)} = \frac{n}{N} \times 100$$

Where n is the number of plants showing blight symptoms and N the total number of plants examined. An average of the ten assessments in the fields represented the average disease incidence of the field.

The Area under disease progress curve (AUDPC) "A" value: The intensity of foliar blight was determined at 10 days interval from the onset of first symptoms until the end of vegetation period (dehaulming) and expressed in per cent of the infected leaf area as per the scale mentioned above in the disease intensity. The Area under disease progress curve (AUDPC) "A" value was determined as per the method given by Shanner and Finney (1997) [11] using the formula. The AUDPC value was calculated with the following formula

$$n-1 = \sum [(X_i+X_i+1)] (T_i+1-T_i)\ i=1\ 2$$

Where
X = % Disease intensity at different dates (X1 + X2, X2 + X3, X3 + X4 … and so on)
T = Time interval between two observations
n = Total number of observations

The per cent yield increase (PYI) was calculated as

$$PYI = \frac{\text{Tuber yield obtained with treatment} - \text{Tuber yield obtained in control plots}}{\text{Tuber yield obtained in control}} \times 100$$

Results and Discussion

The different management components *viz*., tuber dressing with Dimethomorph, soil amendment with *Trichoderma Viride* and FYM, and foliar application of SAR chemical (BTH) and fungicides *viz*. Dimethomorph 50WP and Mancozeb 75WP were integrated and evaluated at Shalimar

and Yarikha separately during 2017 cropping season planting either on susceptible variety Kufri Jyoti or a moderately resistant variety Shalimar.

Disease management using moderately resistant variety

The results of the trial laid at Potato seed Farm Yarikha with moderately resistant variety Shalimar-1 during 2017 (Table-1) revealed that all the treatments proved effective in reducing the late blight incidence in comparison to control. Foliar application with either dimethomorph 50 WP or mancozeb 75 WP alone or in alternation with each other after the application of BTH exhibited least blight incidence of 8.88 to 13.33 per cent, followed by 24.44 per cent obtained in treatments which received foliar application of BTH alone; soil amendments with FYM + *T. Viride* alone, however, yielded 35.55 per cent blight incidence, compared to 53.33 per cent incidence recorded in untreated control. The disease intensity was also the lowest (2.44-2.96%) in treatments receiving the foliar application of both BTH and fungicide mancozeb and dimethomorph compared to check (24.02%); the treatment receiving foliar spray of BTH alone was the next best showing late blight intensity of 13.02 per cent. Similarly the area under disease progress curve ("A "Value) was also the lowest (13.62-15.26%) in treatment receiving in association with soil amendments with FYM and *T. viride*, the foliar application of BTH followed by one or the other fungicide either alone or in alternation with each other. Foliar application with BTH alone exhibited the next lowest "A "value (61.13%) followed by the treatments receiving foliar application with none of the chemicals (76.17%) compared to untreated control (135.33%). The results further indicate a corresponding increase in tuber yield with decrease in blight intensity.

Table-1: Effect of integration of foliar application of BTH and fungicides with dimethomorph tuber treatment and *Trichoderma viride* + FYM soil amendment on progress of late blight and yield of moderately resistant potato cultivar Shalimar-1 at Yarikha during 2017

Treatment		Late blight (%)		"A" value	Tuber yield (q/ha)	Yield gain (%)	**Tuber grade (%)		
		Incidence	Intensity				A	B	C
T_1	Soil amendment (*T.viride* + FYM)	35.55 (36.47)	20.92 (27.18)	76.17	185.02	15.42	13.79	50.76	35.78
T_2	Soil amendment (*T. viride* + FYM)+bth	24.44 (29.46)	13.02 (21.26)	61.13	209.18	30.49	20.41	51.19	28.39
T_3	Soil amendment (*T.viride* + fym) + bth + dimethomorph 50 WP	8.88 (17.10)	2.68 (9.32)	14.45	248.04	54.73	33.23	54.13	12.45
T_4	Soil amendment (*T. viride* + fym) + bth + Mancozeb 75 WP	13.33 (20.97)	2.96 (9.85)	13.62	235.91	47.16	32.43	53.09	14.47
T_5	Soil amendment (*T. viride* + fym) + bth + (Mancozeb 75 WP alternated with Dimethomorph 50WP)	13.33 (20.97)	2.86 (9.70)	15.26	238.07	48.51	35.94	48.26	15.75
T_6	Soil amendment (*T. viride* + fym)+bth+ (Dimethomorph 50 WP alternated with Mancozeb 75 WP)	13.33 (17.50)	2.44 (8.92)	13.71	263.20	64.19	37.57	43.57	8.58
T_7	Control	53.33 (46.95)	24.02 (29.10)	135.33	160.30	-	17.70	43.95	38.37
cd(0.05)		5.91		8.09	16.18		6.54	21.05	10.02

*Recording of data started on May 10th, 2017; data are mean of three replications; figures in parenthesis are arc sin transformed values
** Figures in parenthesis are per cent tuber grade

The treatments receiving soil amendments (*T. viride* +FYM) followed by foliar applications with BTH and either dimethomorph alone or in alternation with mancozeb exhibited the maximum tuber yield of 248.04-263.20 q/ha with 54.73-64.19 per cent yield gain followed by the treatments receiving, after BTH foliar application, the spray of mancozeb either alone or in alternation with dimethomorph (235.91-238.07q/ha with 47.16-48.51% yield gain) compared to untreated control (160.30q/ha). The A grade tubers were also maximum (32.43-37.57% of total yield) and the C grade tubers were minimum (8.58-14.47% of total yield) in the treatments receiving, the foliar application of dimethomorph 50 WP or mancozeb 75 WP either alone or in alternation with each other in addition to soil amendments and BTH sprays compared to untreated control (17.70 and 38.37%), respectively. Similarly the results of the trial laid at Division of Plant Pathology, SKUAST-Kashmir at Shalimar during 2017 (Table-2) revealed that all the treatments proved effective in reducing the blight incidence in comparison to control. Foliar application with either dimethomorph 50 WP or mancozeb 75 WP alone or in alternation with each other after the application of BTH exhibited least blight incidence of 13.33 to 22.22%, followed by 26.66% obtained in treatments which received foliar application of BTH alone; soil amendments with FYM + *T. viride* alone, however yielded 31.10% blight incidence, compared to 33.33% incidence recorded in untreated control. The disease intensity was also the lowest (2.01-3.01%) in treatments receiving the foliar application of both BTH and fungicide mancozeb and dimethomorph compared to check (18.02%); the treatment receiving foliar spray of BTH alone was the next best showing late blight intensity of 12.78%. Similarly the area under disease progress curve ("A "Value) was also the lowest (13.74-16.44) in treatment receiving, in association with soil amendments with FYM and *T. viride*, the foliar application of BTH

Table 2: Effect of integration of foliar application of BTH and fungicides with dimethomorph tuber treatment and *Trichoderma viride* + FYM soil amendment on progress of late blight and yield of moderately resistant potato cultivar Shalimar-1 at Shalimar during 2017

Treatment		Late blight (%)		"A" value	Tuber yield (q/ha)	Yield gain (%)	**Tuber grade (%)		
		Incidence	Intensity				A	B	C
T_1	Soil amendment (*T.viride* + FYM)	31.10 (33.71)	17.10 (24.33)	76.03	172.35	10.53	18.85	49.23	31.91
T_2	Soil amendment (*T. viride* + FYM)+bth	26.66 (30.97)	12.78 (20.75)	53.77	185.36	18.87	21.68	61.85	16.45
T_3	Soil amendment (*T.viride* + fym) + bth + dimethomorph 50 WP	13.33 (20.97)	2.01 (8.06)	13.74	274.41	75.98	38.62	49.98	11.38
T_4	Soil amendment (*T. viride* + fym) + bth + Mancozeb 75 WP	19.99 (26.35)	2.98 (9.71)	16.44	260.00	66.74	38.69	47.96	13.34
T_5	Soil amendment (*T. viride* + fym) + bth + (Mancozeb 75 WP alternated with Dimethomorph 50WP)	22.22 (27.74)	3.01 (9.92)	16.36	264.51	69.63	33.79	51.26	14.93

T_6	Soil amendment (*T. viride* + fym)+bth+ (Dimethomorph 50 WP alternated with Mancozeb 75 WP)	13.33 (20.97)	2.69 (9.12)	15.56	269.29	72.69	43.11	47.08	9.80
T_7	Control	33.33 (35.19)	18.02 (25.09)	104.89	155.93	-	13.53	48.11	38.35
Cd (0.05)		3.41	1.09	11.02	16.08		7.34	19.61	9.53

*Recording of data started on May 10th, 2017; data are mean of three replications; figures in parenthesis are arc sin transformed values
** Figures in parenthesis are per cent tuber grade.

followed by one or the other fungicide either alone or in alternation with each other. Foliar application with BTH alone exhibited the next lowest "A "value (53.77%) followed by the treatments receiving foliar application with none of the chemicals (76.03%) compared to untreated control (104.89%). The results further revealed that a corresponding increase in tuber yield with decrease in blight intensity. The treatments receiving soil amendments (*T. viride* + FYM) followed by foliar applications with BTH and either dimethomorph alone or in alternation with mancozeb exhibited the maximum tuber yield of 269.29-274.41 q/ha with 72.69- 75.98 per cent yield gain followed by the treatments which were receiving, after BTH foliar application, the spray of mancozeb either alone or in alternation with dimethomorph (260-264.51 q/ha with 66.74-69.63 per cent yield gain compared to untreated control (155.90 q/ha). The A grade tubers were also maximum (32.43-37.57% of total yield) and the C grade tubers were minimum (9.30-16.45% of total yield) in the treatments receiving, the foliar application of dimethomorph or mancozeb either alone or in alternation with each other in addition to soil amendments and BTH sprays, compared to untreated control (13.53 and 38.35%), respectively.

Disease management using susceptible potato cultivar

The results of the trial laid at Potato seed Farm Yarikha on susceptible cv. Kufri Jyoti during 2017 (Table-3) revealed that all the treatments proved effective in reducing the blight incidence in comparison to control. Foliar application with either dimethomorph 50 WP or mancozeb 75 WP alone or in alternation with each other after the application of BTH exhibited least blight incidence of 24.44 to 26.66% (Fig-1), followed by 51.11% obtained in treatments which received foliar application of BTH alone; soil amendments with FYM + *T. viride* alone, which resulted up to 62.22 per cent blight incidence, compared to 68.88 per cent incidence recorded in untreated control (Fig-2). The disease intensity was also the lowest (6.68-8.55%) in treatments receiving the foliar application of both BTH and fungicide mancozeb and dimethomorph compared to check (47.78%); the treatment receiving foliar spray of BTH alone was the next best showing late blight intensity of 33.19%.

Table 3: Effect of integration of foliar application of BTH and fungicides with dimethomorph tuber treatment and *Trichoderma viride* + FYM soil amendment on progress of late blight and yield of susceptible potato cultivar cv. Kufri Jyoti at Yarikha during 2017

Treatment		Late blight (%)		"A" value	Tuber yield (q/ha)	Yield gain (%)	**Tuber grade (%)		
		Incidence	Intensity				A	B	C
T_1	Soil amendment (*T.viride* + FYM)	62.22 (52.24)	40.63 (39.55)	210.79	192.51	19.92	18.40	40.64	37.08
T_2	Soil amendment (*T. viride* + FYM) + BTH	51.11 (45.63)	33.19 (35.13)	155.93	219.36	36.65	21.00	49.40	29.08
T_3	Soil amendment (*T.viride* + fym) + bth + dimethomorph 50 WP	26.66 (30.57)	6.68 (14.58)	55.58	273.05	70.10	39.31	49.90	10.79
T_4	Soil amendment (*T. viride* + fym) + BTH + Mancozeb 75 WP	26.66 (30.64)	10.98 (19.10)	73.80	255.89	59.41	38.53	45.44	16.02
T_5	Soil amendment (*T. viride* + fym) + BTH+(Mancozeb75WP alternated with Dimethomorph 50 WP)	26.66 (30.35)	9.19 (17.15)	72.68	235.71	46.84	36.14	43.91	19.93
T_6	Soil amendment (*T. viride* + fym) + BTH + (Dimethomorph 50 WP alternated with Mancozeb 75 WP)	24.44 (29.58)	8.55 (16.83)	61.39	288.10	79.47	42.40	51.48	6.10
T_7	Control	68.88 (56.12)	47.78 (43.74)	250.30	160.52	-	15.44	45.86	38.68
cd(0.05)		3.09	1.37	25.12	9.88		9.31	17.88	8.03

*Recording of data started on May 10th, 2017; data are mean of three replications; figures in parenthesis are arc sin transformed values
**Figures in parenthesis are per cent tuber grade

Similarly, the area under disease progress curve ("A "Value) was also the lowest (55.58-73.80%) in treatment receiving one or the other fungicide either alone or in alternation with each other in association with soil amendments with FYM and *T. viride* and foliar application of BTH followed by the foliar application with BTH alone combined with soil application of FYM and *T. viride* with second lowest "A "value (155.93%) followed by the treatments receiving foliar application with none of the chemicals (210.79%) compared to untreated control (250.30%). The results (Table-3) indicate a corresponding increase in tuber yield with decrease in blight intensity. The treatments receiving soil amendments (*T. viride* + FYM) followed by foliar applications with BTH and either dimethomorph alone or in alternation with mancozeb exhibited the maximum tuber yield of 235.71-288.10 q/ha with 46.84-79.47% yield gain followed by the treatments which received the spray of mancozeb either alone or in alternation with dimethomorph after BTH foliar application (255.89-235.71 q/ha with 46.84-59.41% yield gain), compared to untreated control (160.52 q/ha). The A grade tubers were also maximum (36.14-42.80% of total yield), and the C grade tubers were minimum (6.10-19.93% of total yield)(Fig-3), in the treatments receiving, in addition to soil amendments and BTH sprays, the foliar application of dimethomorph or mancozeb either alone or in alternation with each other compared to untreated control (15.44 and 38.68%), respectively. Similarly, the results of the trial laid at division of plant pathology at Shalimar during same year (Table-4) revealed that all the treatments proved effective in reducing the blight incidence in comparison to control. Foliar application with either dimethomorph 50 WP or mancozeb 75 WP alone or in alternation with each other after the application of BTH exhibited least blight incidence of 22.22 to 28.88 per cent, followed by 55.55 per cent obtained in treatments which received foliar application of BTH alone; soil amendments with FYM + *T. viride* alone, however yielded 64.44 per cent blight incidence, compared to 71.11 per cent incidence recorded in untreated control. The disease

intensity was also found lowest (8.18-11.29%) in treatments receiving the foliar application of both BTH and fungicides mancozeb and dimethomorph compared to check (53.04%); The treatment receiving foliar spray of BTH alone was the next best showing late blight intensity of 38.55%.Similarly the area under disease progress curve ("A "Value) was also the lowest (67.20-79.93%) in treatment receiving, in association with soil amendments with FYM and *T. viride*, the foliar application of BTH followed by one or the other fungicide either alone or in alternation with each other. Foliar application with BTH alone exhibited the next lowest "A "value (179.65%) followed by the treatments receiving foliar application with none of the chemicals (237.29%) compared to untreated control (288.11%). The results (Table-4) indicate a corresponding increase in tuber yield with decrease in blight intensity. The treatments receiving soil amendments (*T. viride* + FYM) followed by foliar applications with BTH and either dimethomorph alone or in alternation with mancozeb exhibited the maximum tuber yield of 199.76 -238.48 q/ha with 33.30- 59.14 per cent yield gain followed by the treatments which received the sprays of mancozeb either alone or in alternation with dimethomorph after BTH foliar application (217.08-223.02 q/ha with 66.74-69.63 per cent yield gain),compared to untreated control (149.85 q/ha). The A grade tubers were also maximum (36.96-40.52%) of total yield and the C grade tubers were minimum (8.30-14.91% of total yield), in the treatments receiving, in addition to soil amendments and BTH sprays, the foliar application of dimethomorph or mancozeb either alone or in alternation with each other compared to un-treated control (18.18 and 37.53%), respectively.

Fig 1: Treatment plot of susceptible cultivar Kufri Jyoti T_6- (Soil amendment + BTH foliar spray+ spray with Dimethomorph 50 WP alternated With Mancozeb 75 WP)

Fig 2: Untreated Control plot

Fig 3: Proportion of unmarketable (grade C) and marketable(grade A &B) tubers of Kufri Jyothi cultivar

Table 4: Effect of integration of foliar application of BTH and fungicides with dimethomorph tuber treatment and *Trichoderma viride* + FYM soil amendment on progress of late blight and yield of susceptible potato cultivar cv. Kufri Jyoti at Shalimar during 2009

	Treatment	Late blight (%)		"A" value	Tuber yield (q/ha)	Yield gain (%)	**Tuber grade (%)		
		Incidence	Intensity				A	B	C
T_1	Soil amendment (*T. viride* + FYM)	64.44 (53.51)	45.98 (42.53)	237.29	163.40	9.04	21.87	47.96	30.26
T_2	Soil amendment (*T. viride* + FYM)+ BTH	55.55 (48.24)	38.55 (38.55)	179.65	169.57	13.15	24.36	47.96	28.63
T_3	Soil amendment (*T. viride* + fym) + bth + dimethomorph 50 WP	24.44 (29.07)	8.18 (16.34)	68.45	223.02	48.82	36.96	52.90	10.13
T_4	Soil amendment (*T. viride* + fym) + BTH + Mancozeb 75 WP	28.88 (32.29)	11.29 (19.51)	79.93	217.08	44.86	37.20	51.55	11.20
T_5	Soil amendment (*T. viride* + fym) + BTH+(Mancozeb75WP alternated with Dimethomorph 50 WP	24.44 (29.58)	9.39 (17.57)	75.27	199.76	33.30	37.90	47.17	14.91
T_6	Soil amendment (*T. viride* + fym) + BTH + (Dimethomorph 50 WP alternated with Mancozeb 75 WP)	22.22 (27.24)	8.58 (16.83)	67.20	238.48	59.14	40.52	51.32	8.30
T_7	Control	71.11 (57.51)	53.04 (46.75)	288.11	149.85	-	18.18	44.27	37.53
cd(0.05)		3.91	2.11	25.12	16.18		8.11	17.53	9.06

*Recording of data started on May 10th, 2017; data are mean of three replications; figures in parenthesis are arc sin transformed values.
**Figures in parenthesis are per cent tuber grade

The effective components of disease management such as host resistance, soil amendments, bio-agents, chemical fungicides and SAR inducers, are envisaged to provide cumulative dividends when integrated logically as a component of production package. The integration of these components for managing the disease in a moderately resistant variety Shalimar I and susceptible var. Kufri Jyoti during the present investigation revealed that foliar application of both BTH and mancozeb and also dimethomorph exhibited the lowest disease intensity of 2.44-2.96% compared to check (24.02%). Besides, soil amendments with FYM+ *T. viride* and foliar application of BTH followed by one or the other fungicide either alone or in alternation with each other exhibited the least "A" value (14.62-15.28) with concomitant yield gains and improvement in tuber grades. It was also found that Moderately resistant variety Shalimar-1 exhibited very less disease intensity, incidence and 'A'value compared to susceptible cultivar kufri jyothi when provided with similar treatments at both locations i.e Shalimar and Yarikha in Kashmir. The integrated management of the disease has been studied by several other workers where considerable reduction in disease intensity and A value with corresponding increase in the yield and tuber grade has been obtained by integration of two or more of the identified components compared to the use of a single or few components (Lal *et al.*, 2017; Majeed *et al.*,2017; Kumar *et al.*, 2006; Andreu *et al.*, 2006; Basu and Das 2003) [7, 8, 6, 1, 3]. Gudero, 2017 also studied the integration of host resistance, cultural manipulation, bio-agents and chemicals and succeeded in a reducing the late blight to 6-7%. The present studies were also found to be in agreement with the above findings. Ultimately end results of this study proved that, host resistance to the pathogen infection and spread, suppression of the pathogen survival in soil and propagating material using organic soil amendments enriched with bio-agents, induction of systemic acquired resistance in host and last but not least, timely and recommended use of fungistats, fungicides and chemotherapeutants by optimizing their dosages, all when combined in logical pattern can pave way for efficient and sustainable management of such infectious ailments.

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