

## Eco-Friendly Strategies to Suppress the Development of *Alternaria* Blight and Black Rot of Cauliflower

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**Abstract:** An attempt was made to study the efficacy of various cultural practices such as covering the cauliflower nursery with nylon net, growing nursery under poly cover, use of hessian cloth (shelter belt) in the field and removal of diseased foliage (different level) on the development of *Alternaria* blight and black rot diseases of cauliflower. Covering the nursery with nylon net had a retarding effect on disease development. The periodic intensity of *Alternaria* blight in cauliflower having up to 10, 10-25 and 25-50 per cent removal of diseased leaves was 35.55, 28.00 and 17.33 per cent, respectively while that in the control was 47.33 per cent. Since the incidence of black rot was only incipient, the numbers of diseased leaves clipped-off were quite low without any consistency in the disease progress trend. The terminal intensity of *Alternaria* blight recorded at a distance of 2, 4 and 6 m from the shelterbelt (hessian cloth) after 35 days was 26.00, 28.67 and 29.33 per cent, respectively, while that without any shelterbelt was 35.33 per cent. The mean reduction in the intensity of the disease after 35 days was 26.42, 18.87 and 16.98 per cent at a distance of 2, 4 and 6 m from the shelterbelt, respectively. Similarly, black rot concentration was found more near the shelterbelt and the number of diseased plants considerably reduced with their location away from the shelterbelt. On an average, nursery plants of cauliflower under nylon cover registered a disease intensity of 14.9 per cent that was lesser than that of uncovered plants (22.8 %) by about 35 per cent. The raising of nursery under polytunnel was, however, not found advantageous as the seedlings became lanky and chlorotic being unworthy for transplanting. The results obtained from the present study suggested that these cultural practices can be conditioned for their effective use for eco-friendly disease management in the field either alone or as a component of integrated disease management.

**Key words:** *Brassica oleracea* • *Xanthomonas campestris* • *Alternaria brassicicola* • cultural practices  
• shelterbelt

### INTRODUCTION

Cauliflower (*Brassica oleracea* L. var. *botrytis* subvar. *cauliflora*), is one of the important winter vegetable crops cultivated throughout the world. In India, cauliflower representing different maturity groups is available around the year. Its commercial cultivation is limited by various factors amongst which diseases play an important role. The crop is subject to attack by a variety of pathogens both in the nursery as well as in field. *Alternaria* blight [*Alternaria brassicae* (Berk.) Sacc., *Alternaria brassicicola* (Schwein) Wiltshire] and black rot [*Xanthomonas campestris* pv. *campestris* Pammel Erco Sm.] are the most common and serious diseases that appear almost synchronously on the same host causing extensive losses in yield and quality of curds in the

vegetable crops and seed yield and vigour in the seed crop [1-2].

*Alternaria* blight causing leaf spotting, pre-mature defoliation and curd deterioration has been reported to cause as high as 80 per cent reduction in seed yield [3]. Similarly, black rot is also a serious disease at seedling and planting stage and the infection resulting from infected seeds. Under severe outbreak of this disease, substantial reduction in yield to tune of 5 to 70 per cent has been reported [4]. The prior infection of black rot predisposes plants for increased infection of *Alternaria* blight [5]. This demands that the dynamics of the diseases occurring together should be studied simultaneously in relation to their control measures. However, the disease control recommendations are available for the control of individual diseases. For the control of *Alternaria* blight

dithiocarbamates and of black rot bactericides such as streptocycline and copper based compounds are generally recommended. But the use of chemicals in edible fresh vegetable crops is not encouraged owing to ecological and economic reasons. These diseases can be effectively managed by use of mancozeb belonging to ethylene bis-dithiocarbamate (EBDC) group of fungicides [6]. Though EBDC fungicides have low mammalian toxicity yet its decomposed product ethylene thiourea (ETU) is reported to be carcinogenic [7]. In general, the commercial vegetable growers have the tendency to give more number of sprays and use higher dose of fungicides than the recommended ones for disease control, which leads to the development of residues in the consumable parts of vegetables. The excessive use of these fungicides also results in the development of resistance among the plant pathogen which necessitated the need to look for eco-friendly, safer and effective methods of disease control.

In the present study, evaluation of various cultural practices for suppression of disease development of Alternaria blight and black rot was undertaken. The study also focused on whether the cultural practices can be considered for integrated eco-friendly disease management of Alternaria blight and black rot of cauliflower.

## MATERIALS AND METHODS

**Experimental Location:** The field experiment was conducted at the Vegetable Research Farm of the Punjab Agricultural University (PAU), Ludhiana, India. Ludhiana is situated at 30°-57'N and 75°-56'E and 247 m above sea level. The region has a typical subtropical climate with low winter temperature and high May-June temperatures associated with hot winds. The soil was sandy loam with mild alkaline reaction (pH= 8.2), low organic carbon (0.33 %) and medium P (19.3 kg ha<sup>-1</sup>) and K (185 kg ha<sup>-1</sup>) availability.

**Plant Materials and Experimental Design:** The seed of cv. 'Pusa Giant-26' was sown in the first week of October on raised beds. The seedlings were transplanted in the field during the second week of November, 35-40 days after sowing. The row-to-row and plant-to-plant spacing was 60 and 45 cm, respectively. Treatments were replicated thrice in a randomized block design (RBD) with a gross and net plot size of 17.44 square meters and 16.20 squares meters, respectively. The fertilizer and other agronomic practices were followed as per local recommendation [8].

To study the effect of shelter belt on the development of black rot and Alternaria blight, hessian cloth measuring 1.5 m in height and 6m in length was provided on the south-west side of the experimental plot with the help of wooden sticks during the period from November to February. The intensity of both the diseases was recorded at a distance of 2, 4 and 6 m from the shelter belt at weekly interval and compared with that in the control where no shelter belt was provided. The mean daily rate of infection (r) was calculated as per the formula given by van der Plank [9].

The cauliflower plot was covered with nylon net during November to study its impact on the appearance and spread of Alternaria blight and black rot diseases. The cauliflower seedlings raised in the open without any cover served as control. The intensity of Alternaria blight and black rot was recorded at weekly intervals and compared with that in the control. The daily rate of infection (r) was calculated [9].

The effect of clipping of the diseased foliage on the progression of Alternaria blight and black rot complex was studied on 30day old plants. For this, ten seedlings were randomly selected. The total numbers of healthy and diseased leaves were counted during the month of November and the diseased leaves were manually removed up to 10, 10-25 and 25-50 per cent. The seedlings with no leaf removal served as control. The disease intensity was recorded at weekly interval and per cent disease reduction was worked out.

**Disease Assessment:** The per cent disease intensity (PDI) was computed as:  $PDI = 100 [(sum\ of\ numerical\ rating) / (5N)^{-1}]$  [5], where N is the number of observations and 5 is the maximum class rating. The disease intensity (PDI) was calculated as percentage of infected leaves of cauliflower. For the calculation of coefficient of disease (CODEX), disease intensity (PDI) was multiplied with disease incidence (PID). For computing the PDI, 0-5 scale was used as follows:

- 0 = No disease
- 1 = Up to 20 per cent leaf area under symptoms
- 2 = Between 20-40 per cent leaf area under symptoms
- 3 = Between 40-60 per cent leaf area under symptoms
- 4 = Between 60-80 per cent leaf area under symptoms
- 5 = > 80 per cent leaf area under symptoms

The per cent disease reduction (PDR) in each treatment was calculated by using the formula as:  $PDR = 100 [(D_c - D_t) (D_c)^{-1}]$  where,  $D_c$  = disease intensity in control,  $D_t$  = disease intensity in treatment.

**Statistical Analysis:** All the experiments results were subjected to CPCS1 computer based statistical analysis software. Data on per cent age were transformed in arcsine and analysis of ANOVA was carried out with transformed values. The means were compared to significance ( $p=0.05$ )

## RESULTS AND DISCUSSION

Effect of clipping of diseased foliage at different levels, erection of shelter belt, raising nursery under cover of polyhouse / poly tunnel and nylon netting was studied on the development of Alternaria blight and black rot diseases. The results are presented and discussed here under:

**Removal of Diseased Foliage:** The removal of diseased foliage to different extent was examined in relation to the development of Alternaria blight and black rot under field conditions. The data on the effect of clipping-off of diseased foliage on the intensity of Alternaria blight are given in Table 1. The treatments varied significantly in their effect in suppressing disease development. The treatment, observation date and their interaction were statistically significant. From the data presented (Table 1), it is evident that the terminal intensity of Alternaria blight in cauliflower plants subjected to 10, 10-25 and 25-50 per cent removal of diseased leaves was 35.55, 28.00

and 17.33 per cent, respectively while that in the control was 47.33 per cent. This reduced intensity of Alternaria blight could be due to diminished availability of inoculum as the clipping-off of diseased foliage removes the inoculum load from the host [10-11]. The diseased foliage if not removed would fall as debris on the soil and act as reservoir of secondary infections at field floor [12].

In the present investigation, the mean reduction in the intensity of Alternaria blight was 21.87, 45.42 and 66.04 per cent in case of plants subjected upto 10, 10-25 and 25-50 per cent removal of diseases leaves, respectively (Table 1). The plants could withstand a higher level of clipping upto 50 per cent, as they did not reveal any adverse effect on yield or stress symptoms. The mean intensity of the disease was 4.50, 11.00, 20.00, 25.83 and 32.00 per cent after 7, 14, 21, 28 and 35 days of clipping (Table 1). Since the incidence of black rot was only incipient, the number of diseased leaves clipped-off were quite low without any well defined disease progress trend. The removal of infected foliage from the field can suppress the disease development, as they are the major source of infection. Even the diseased leaves fallen as debris in the soil act as reservoir of black rot infection [12-13].

There are many instances to support that removal of infected plants and infected plant parts have helped in reducing the amount of inoculum of the pathogen, arresting the disease development in several crops. In hops, manual removal of basal growth (upto 4 feet from the soil line) effectively reduced downy mildew (*Pseudoperonospora humuli*) severity in the United States [10]. Likewise, removal of host foliage helped to reduce *Sclerotinia* rot (*Sclerotinia sclerotiorum*) in

Table 1: Effect of clipping-off of diseased foliage on the development of Alternaria blight of cauliflower

Clipping of diseased foliage (%)	Intensity of Alternaria blight (%) after days					Mean reduction (%)
	7	14	21	28	35	
	4.67 (12.03)	12.67(20.75)	26.67 (31.08)	31.33 (34.02)	35.33 (36.39)	22.13
Upto 10	46.07**	23.95**	2.63**	11.32**	25.35**	21.87**
	3.33 (10.40)	10.00 (18.37)	14.00 (21.32)	22.66 (28.40)	28.00 (31.93)	15.47
10-25	61.55**	39.98**	48.89**	35.86**	40.84**	45.42**
	1.33 (5.72)	5.33 (12.91)	12.66 (20.79)	14.0 (21.83)	17.33 (24.50)	10.13
25-50	84.64**	68.01**	53.78**	60.37**	63.38**	66.04**
Control*	8.66 (17.01)	16.66 (23.46)	27.39 (31.51)	35.33 (36.45)	47.33 (43.45)	
CD ( $p=0.05$ )	Clipping	=	2.10			
	Day	=	2.35			
	Clipping x day	=	NS			

\* No leaf removal

\*\* Figures showing percentage (%) reduction over control

Table 2: Effect of shelter belt (hessian cloth) on the development of Alternaria blight of cauliflower

Distance from Shelter belt (m)	Intensity of Alternaria blight (%) after days					Mean
	7	14	21	28	35	
2	2.67 (6.55)	8.67 (17.09)	14.67 (22.50)	18.67 (25.54)	26.00 (30.61)	11.94
	73.33**	53.57**	40.54**	37.78**	26.42**	46.33**
4	4.67 (12.41)	13.33 (21.40)	16.00 (23.54)	22.67 (28.40)	28.67 (31.51)	15.22
	53.33**	28.57**	35.14**	24.44**	18.87**	32.07**
6	8.00 (16.34)	16.00 (23.46)	20.67 (27.01)	24.67 (29.75)	29.33 (32.72)	18.28
	20.00**	14.29**	16.22**	17.78**	16.98**	17.05**
Control*	10.00 (18.37)	18.67 (25.58)	24.67 (29.76)	30.00 (33.19)	35.33 (36.42)	22.44
Infection rate (R) ***						
2	-	0.180	0.085	0.041	0.061	
4	-	0.160	0.032	0.061	0.045	
6	-	0.112	0.044	0.032	0.034	
CD (p=0.05) Distance	=	2.43				
Day	=	2.17				
Distance x day	=	4.86				

\* Without shelter belt

\*\* Figures showing per cent reduction over control

\*\*\* Figures in parenthesis after arc sine transformation

oilseed rape plants [11]. Marketable yield of potatoes was significantly increased by five weekly removals of leaves infected with late blight pathogen (*Phytophthora infestans*). The fungicide application (metalaxyl) could reduce the disease effectively when the chemical application was combined with the removal of infected leaves [14].

In rapeseed and mustard, removal of 50 per cent lower leaves of 50-60 day old crop increased seed yield on account of reduced foliar diseases [15]. Similarly, Koul and Singh [16] reported a significant interaction between date of sowing and removal of lower leaves as cultural management practices vis-à-vis severity of Alternaria blight, white rust and downy mildew diseases. The removal of diseased foliage can increase the efficacy of chemical control of the disease as fungicide spray will have the target relatively less pathogen inoculum [14]. The present findings, therefore, indicate that reduction in the inoculum by clipping-off of diseased leaves can be viewed from the point of their inclusion in the integrated diseased management options [16].

**Effect of Shelter Belt:** The data showing the effect of shelter-belt (Hessian cloth) on the development of Alternaria blight are presented in Table 2. The periodic intensity of disease gradually and significantly increased with distance from the shelterbelt. The terminal intensity of Alternaria blight recorded at a distance of 2, 4 and 6 m from the shelterbelt after 35 days was 26.00, 28.67 and

29.33 per cent respectively, while that without any shelterbelt was 35.33 per cent (Table 2). The disease intensity was significantly reduced in all the three treatments as compared to control, where no shelterbelt was used (Table 2). The mean reduction in the intensity of the disease after 35 days was 26.42, 18.87 and 16.98 per cent at a distance of 2, 4 and 6 m from the shelterbelt, respectively. This reduced intensity of Alternaria blight might be due to protection provided by the shelter belt against the wind-driven rains [17]. Shelterbelt, for these reasons, caused retardation in the disease dynamics with time.

Cauliflower crop subjected to protection by the shelterbelt on an average regulated a disease intensity of 6.33, 14.17, 19.00, 24.00 and 29.83 per cent after 7, 14, 21, 28 and 35, days, respectively (Table 2). The effect of distance from shelterbelt, observations date and their interactions were also statistically significant (Table 2).

The mean daily infection rate (r) of Alternaria blight was considerably reduced at a distance of 2-6 m from the shelter belt after a period of 2-5 weeks but the rate further decreased with distance from the shelter-belt (Table 2). This decrease in the value of 'r' reflects the protection rendered by shelter-belt by acting as a curtain against wind and rain splash loaded with inoculum [18].

Although black rot incidence was low, its concentration was more near the shelterbelt and the number of diseased plants considerably reduced with their location away from the shelterbelt. The spread of

Table 3: Development of Alternaria blight on cauliflower as influenced by nylon covering

Periodv (Week)	Under nylon cover	Intensity (%) of Alternaria blight		** Infection rate per day	
		Control*	Mean	Under nylon cover	Control*
1	2.00 (6.55)	6.00 (14.04)	4.00 (10.29)	-	-
2	9.33 (17.52)	16.67 (24.08)	13.00 (20.80)	0.163	0.231
3	15.33 (23.01)	25.33 (30.63)	20.67 (26.82)	0.075	0.081
4	21.33 (27.00)	28.67 (32.36)	24.67 (29.67)	0.024	0.058
5	28.67 (31.51)	31.67 (37.25)	30.17 (34.38)	0.016	0.051
Mean	14.93 (21.12)	22.80 (27.67)			
CD (p=0.05)	Nylon cover	= 1.41			
	Week	= 2.42			
	Nylon x Week	= NS			

\* Without cover

\*\* Calculated after Vander Plank (1963)

\*\*\* Figure in parenthesis after arc sine transformation

bacterial black rot in the field on single plant is aided primarily by of contaminated raindrops and condensation water. Dispersal of the bacterium over greater distances is due to the combined effect of flow of contaminated water droplets, rain splashes and windy conditions [19]. The magnitude of dispersal varies with the intensity of wind-driven rains and accompanying inoculum. Thus, shelterbelt can minimize disease development through acting as a curtain to the moving wind-driven rain loaded with inoculum. According to Carissie and colleagues [19] black rot pathogen can travel at a distance of about 8 m during major storms, which the shelter belt could protect against, as in the present study. Singh [18] also studied the effect of shelterbelt (hessian cloth) on the development of bacterial canker and fungal scab complex in citrus nursery and reported that the shelter belt provided protection by acting against wind-driven rains.

To compare the rate of development of the test disease as influenced by distance from the shelterbelt, daily mean infection rate (r) for a compound interest disease (Alternaria blight) and simple interest disease (black rot) was worked out as per van der Plank [9]. The results are in the line with those obtained by Bal and Dhiman [17]. They worked out the mean daily infection rate (r) of the canker scab complex that was considerably reduced at 2 m distance after seven weeks and showed that the rate increased with distance from the shelterbelt. The fast spread of fungal and bacterial pathogens from plant to plant and rain splashes had been reported by many workers [20-21].

**Raising Nursery / Plants under Cover:** The nursery plants were protected against initial infection by providing them a cover of nylon netting and polytunnel

because the protected nursery is expected to perform better under field conditions due to their vigorous and disease-free growth.

**Effect of Nylon Cover on Disease Development:** Data on the effect of nylon net on the development of Alternaria blight are presented in Table 3. Under nylon cover, the intensity of the disease was 2.0, 9.33, 15.33, 21.33 and 28.67 per cent after 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup> and 5<sup>th</sup> week of coverage, respectively. The corresponding figures for the plants not covered with nylon net were 6.00, 16.67, 25.33, 28.67 and 31.67 per cent (Table 3). From these data it is evident that covering the plants with nylon net caused a significant reduction in the development of Alternaria blight over a period of 5 weeks (Table 3). The intensity of the disease, irrespective of the cover was 4.00, 13.00, 20.67, 24.67 and 30.17 per cent on 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup> and 5<sup>th</sup> week, all values being different statistically from each other. On an average, plants under nylon covering registered a disease intensity of 14.9 per cent that was lesser than that of uncovered plants (22.8 %) by about 35 per cent (Table 3).

To examine whether the nylon cover caused retardation in disease development, the rate of infection (r) per day for first-second week, second-third week, third-fourth week and fourth-fifth week was found out as 0.163, 0.075, 0.024 and 0.016, respectively (Table 3). It indicated that the spread of the disease slowed down after second week. The corresponding values of 'r' was 0.231, 0.081, 0.058 and 0.051 for uncovered plants (Table 3). Thus cover with nylon net can be a useful cultural practice to protect the seedlings against Alternaria blight at least when these are still in the nursery bed. More over, black rot is an internally seed-borne disease [22]. There was very few diseased plants in the nursery provided with the nylon cover. The disease, however, did not show any

marked progress with time, till the seedlings were transplanted. It is likely that the seed-lot used for raising nursery might be having seed-borne inoculum.

The nylon cover helped to maintain a temperature below the optimum for the disease development. The temperature of 25-28 °C coupled with high humidity and rainy conditions are conducive for the development of black rot [19]. The experimental material did not have these conditions and therefore the disease might not have spread further in the seedling populations. Several reports (17-18, 23-24] with respect to the protection of plants against fungal and bacterial diseases are available in literature.

**Effect of Raising Nursery under Polyhouse:** The raising of cauliflower nursery under polytunnel was not found advantageous as the seedlings became lanky and chlorotic which were unworthy for transplanting. This was due to the less light (sub-optimal photoperiod), increased humidity and high temperature (46±2 °C) that prevailed inside the tunnel. There was high incidence of damping-off. So the progress of the experiment was not considered worthwhile as Humpherson and co-workers [25] also observed that a temperature of 15°C together with a minimum wetness period of 16 h is required for infection of cabbage (*Brassica oleracea* L) leaves.

These findings indicate a possibility of protecting the crop from *Alternaria* blight and black rot through cultural practices like providing a nylon or polythene cover, at least for the initial phase of disease development from the nursery. In the light of present findings, it would be essential to make rectification in the photoperiod, through artificial light arrangement, so as to ensure good growth of the seedlings and to have the desirable results.

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