

Control of damage agents on cabbage and cauliflower crops under high plastic tunnels

A.E. Cenușă*, S.Ș. Hogeă, G. Șovărel and M. Costache

Research and Development Institute for Vegetable
and Flower Growing Vidra, Romania

*Corresponding author email: ema_april@yahoo.com

ABSTRACT

The study was conducted in 2022, under high plastic tunnel-conditions, at the Research and Development Institute for Vegetable and Flower Growing Vidra, aiming to evaluate the effectiveness of an integrated pest and disease management program in cabbage and cauliflower crops. Seven commercial hybrids were tested under two variants: a treated variant (V1), which received a complete sequence of chemical and biological plant protection products, and an untreated control (V2). The cabbage hybrids included 'Delight Ball F1', 'Vettel F1', 'Zarissima RZ F1' and 'Magnus Cresco F1', while the cauliflower hybrids were 'Freedom F1', 'Arienzo RZ F1' and 'Venoosa F1'. In cabbage, the main pathogens identified were *Xanthomonas campestris*, *Alternaria brassicae* and *Sclerotinia sclerotiorum*, together with the pests *Brevicoryne brassicae*, *Phyllotreta atra* and *Pieris brassicae*. In cauliflower, *X. campestris* and *A. brassicae* were present, along with *P. atra*, *P. brassicae* and *Plutella maculipennis*. The protection program ensured high control efficacy, ranging from 78–89% for pathogens and pests in cabbage and 84–97% in cauliflower. Yield results reflected the effectiveness of the treatments. In cabbage, yields increased significantly in all hybrids, with the highest value recorded in "Delight Ball F1" (9.160 kg/m²). In cauliflower, the highest yield was obtained in "Freedom F1" (6.110 kg/m²), with significant and distinctly significant differences from the untreated control. Overall, the integrated protection program demonstrated high efficiency in reducing disease and pest incidence and significantly improving yields under high plastic tunnel cultivation.

Keywords: fungicides, insecticides, pathogens, pests, efficacy.

INTRODUCTION

Cabbage and cauliflower crops under high plastic tunnels are frequently attacked by the pathogens *Xanthomonas campestris*, *Alternaria brassicae*, *Sclerotinia sclerotiorum* and the pests *Brevicoryne brassicae*, *Phyllotreta atra*, *Pieris brassicae* and *Plutella maculipennis* which reduce yield quantitatively and it depreciates qualitatively (Costache *et al.*, 2023).

Both "bio" products (different microorganisms with antagonistic effect, plant extracts) and chemical products are used to control these damage agents.

The biological agents *Azotobacter chroococcum*, *Bacillus megaterium*, *Agrobacterium radiobacter*, *Pseudomonas fluorescens*, *Pseudomonas auerofaciens*, *Bacillus subtilis* and *Trichoderma lignorum* have been studied to control the pathogens *Xanthomonas campestris* pv. *campestris*, *Alternaria brassicae* and *Sclerotinia sclerotiorum* on cabbage. They effectively limited

the development of bacterial and fungal diseases on cabbage, their protective effect against bacterial diseases being 65-79% and against fungal diseases 45-62% (Serhiienko *et al.*, 2023).

The products azoxystrobin 25% and azoxystrobin 20% + difenconazole 12.5% were the most effective in completely inhibiting the mycelial growth of *Alternaria brassicae* in cauliflower (Chandel *et al.*, 2023).

Experiments undertaken under laboratory conditions with chemical-based (lambda cyhalothrin and emamectin benzoate) and "bio" products (*Azadirachta indica* neem seed extracts, *Dodonaea angustifolia* fresh hop leaves and *Cymbopogon citratus* lemon grass) had positive performances in control of the *Brevicoryne brassicae* pest (Shiberu and Negeri, 2016).

The cabbage moth (*Plutella maculipennis*) is one of the most important pests of cruciferous crops, causing economic losses of over 90% (Tolessa *et al.*, 2021).

Cabbage white butterfly (*Pieris brassicae*) is an important pest of plants in the Brassicaceae family (Shikha *et al.*, 2023), attacking and causing significant damage on cabbage, cauliflower, mustard and radish (Iablonec *et al.*, 2022).

Fleas of the genus *Phyllotreta* are major pests of brassica vegetable crops, therefore their control is mainly based on conventional methods, available insecticides having limited effectiveness due to the development of resistance in pest populations (Li *et al.*, 2024).

In the paper, the efficacy of treatments with chemical and "bio" products used to control pathogens and pests specific to cabbage and cauliflower crops were tracked.

MATERIALS AND METHODS

Experimental site and growing conditions

The experiments were carried out in 2022 at the Research and Development Institute for Vegetable and Flower Growing Vidra (R.D.I.V.F.G.), under high plastic tunnel conditions. The tunnel measured 50 m × 10 m × 5 m, covered with anti-condensation polyethylene and equipped with frontal and lateral ventilation.

Temperature and relative humidity were automatically monitored using a CEM DT-172 thermohygrometer, recording averages of 9.7°C (minimum), 21.2°C (mean), 36.0°C (maximum) and 32.7%, 63.7%, 90.3%, respectively, during the experimental period.

Plant material. The biological material used in this study consisted of seven commercial Brassica hybrids, belonging to two crop types cultivated under protected conditions: Cabbage (*Brassica oleracea* var. *capitata*) with the cultivars 'Delight Ball F1', 'Vettel F1', 'Zarissima RZ F1', 'Magnus Cresco F1' and Cauliflower (*Brassica oleracea* var. *botrytis*), with the 'Freedom F1', 'Arienzo RZ F1', 'Venoosa F1'.

Seeds of all hybrids were sown on 24 February 2022 in alveolar trays filled with a commercial horticultural substrate enriched with a balanced fertilizer mixture. Seedlings were maintained under controlled protected conditions until transplanting.

Transplanting into the high plastic tunnel was carried out on 29 March 2022, using uniform and healthy seedlings. All hybrids were grown under the same environmental and cultural conditions to ensure the comparability of experimental data.

Experimental design. The study was conducted using a comparative two-variant design, applied separately to each of the cabbage and cauliflower hybrids included in the experiment. The two experimental variants were: V1 – Treated - plants protected using the complete plant protection program, and V2 – Untreated (Control): plants grown without any plant protection treatments (Table 1).

The Treated variant (V1) consisted of a fully integrated protection program, combining chemical and "bio" products applied sequentially throughout the vegetation period.

Table 1. Description of experimental variants and treatments applied

Variant	Description	Treatments applied	Purpose
V1 – Treated	Plants protected using complete plant protection program	Amistar 0.1%, Funres 0.3%, Decis Expert 100 EC 0.0075%, Mavrik 2F 0.05%, Flipper 2.0%, Neemex 0.3% + Break-Thru S240 0.02%	Evaluation of the integrated control program for pathogens and pests
V2 – Untreated (Control)	Plants without any plant protection treatments	(Control variant)	Baseline reference to assess attack severity and yield reduction

Depending on crop needs and the presence of pathogens and pests, the treatments included: chemical fungicides, bio - fungicides/bactericides, chemical insecticides, bio insecticides, all applied with Break-Thru S240 adjuvant (0.02%). The products used in V1—active substances, concentrations, action spectrum, and pre-harvest intervals (Table 2).

Table 2. Products used to control pathogens and pests on cabbage and cauliflower crops

Product	Active substance	Concentration (%)	Action spectrum	Break time (days)
a. Chemical-based fungicides				
Amistar	azoxystrobin 250g/l	0.1	<i>Alternaria brassicae</i> , <i>Sclerotinia sclerotiorum</i>	14
b. "Bio" fungicides				
Funres	<i>Mimosa tenuifolia</i> extract 60% + citrus extract 20%	0.3	<i>Xanthomonas campestris</i> , <i>Alternaria brassicae</i> , <i>Sclerotinia sclerotiorum</i>	0
c. Chemical based insecticides				
Decis Expert 100 EC	deltamethrin 100g/l	0.0075	<i>Pieris brassicae</i> , <i>Plutella maculipennis</i> , <i>Phyllotreta atra</i>	7
Mavrik 2F	tau-fluvalinate 240g/l	0.05	<i>Pieris brassicae</i> , <i>Plutella maculipennis</i>	7
d. "Bio" insecticides				
Flipper	potassium salts of fatty acids C7-C18, 479,8 g/l	2.0	<i>Brevicoryne brassicae</i>	0
Neemex	<i>Neem saponi</i> seed extract	0.3	<i>Brevicoryne brassicae</i> , <i>Pieris brassicae</i>	0

The treatments in the Treated variant (V1) followed a sequential application scheme (T1–T6), implemented according to the incidence and intensity of pest and pathogen attacks. Each treatment code corresponds to a specific product, concentration, application date, and biological target.

Chemical treatments were applied at 7–10 day intervals, whereas “bio” products were applied at 4–6 day intervals, in accordance with recommended use in protected cultivation systems, (Table 3).

Untreated variant (V2 – Control). The control variant consisted of plants that did not receive any chemical or biological plant protection treatments throughout the entire crop cycle. Only standard cultural practices (ventilation, irrigation, fertilization, and hygiene) were applied, and the natural development of pathogens and pests was allowed.

Table 3. Fungicide, bio-fungicide, insecticides and bio-insecticides treatments applied for pathogens and pests control

Treatment	Product	Concentration	Dates applied	Target pathogen(s)	Crop
T1	Amistar Decis Expert 100 EC	0.1% 0.0075%	05 May 20 April	<i>Alternaria brassicae</i> , <i>Sclerotinia sclerotiorum</i> <i>Pieris brassicae</i> , <i>Plutella</i> <i>maculipennis</i> , <i>Phyllotreta atra</i>	Cabbage Cauliflower
T2	Amistar Mavrik 2F	0.1% 0.05%	13 May 02 May	<i>A. brassicae</i> , <i>S. sclerotiorum</i> <i>P. brassicae</i> , <i>P. maculipennis</i>	Cabbage Cauliflower
T3	Funres Decis Expert 100 EC	0.3% 0.0075%	20 May 12 May	<i>Xanthomonas campestris</i> , <i>A. brassicae</i> , <i>S. sclerotiorum</i> <i>P. brassicae</i> , <i>P. maculipennis</i> , <i>P. atra</i>	Cabbage Cauliflower
T4	Funres Flipper	0.3% 2.0%	25 May 24 May	<i>X. campestris</i> , <i>A. brassicae</i> , <i>S. sclerotiorum</i> , <i>Brevicoryne</i> <i>brassicae</i>	Cabbage Cauliflower
T5	Funres Flipper	0.3% 2.0%	30 May 31 May	<i>X. campestris</i> , <i>A. brassicae</i> , <i>S. sclerotiorum</i> , <i>B. brassicae</i>	Cabbage Cauliflower
T6	Funres Neemex	0.3% 0.3%	08 June 10 June	<i>X. campestris</i> , <i>A. brassicae</i> , <i>S. sclerotiorum</i> , <i>B. brassicae</i> , <i>P. brassicae</i>	Cauliflower

This variant provided the baseline reference for evaluating the degree of attack by pathogens and pests, and the difference in yield between protected and unprotected plants.

RESULTS AND DISCUSSIONS

The temperature dynamics recorded inside the high plastic tunnels showed a clear increasing trend from late March to mid-June (Figure 1). Minimum temperatures ranged from approximately 5–7°C in late March and early April to 14–16°C in June. Mean temperatures followed a similar pattern, rising gradually from 15–20°C in March–April to 24–27°C in June. Maximum temperatures were consistently high throughout the entire experimental period, oscillating between 32°C and 39°C, with peak values recorded in June. These elevated maximum temperatures are characteristic of protected cultivation systems during late spring and early summer. Overall, the progressive increase in both minimum and mean temperatures ensured favourable thermal conditions for vegetative growth, while the periodically elevated maximum temperatures may have contributed to enhanced pest and pathogen activity, supporting the natural pressure required for evaluating the effectiveness of the protection program.

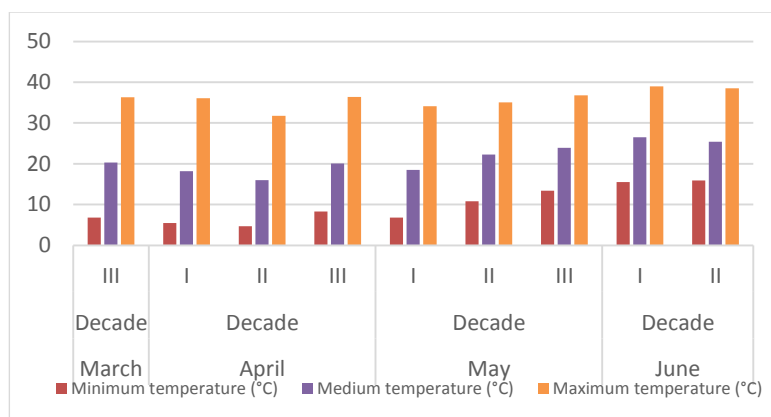


Figure 1. Temperature during experimental trials under a high plastic tunnel

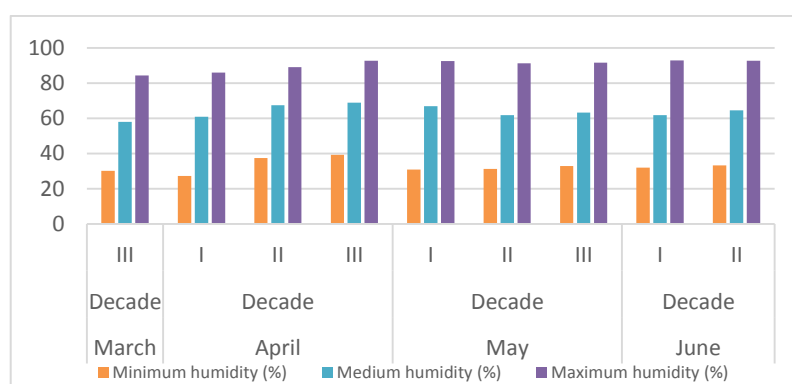


Figure 2. Relative air humidity during experimental trials under a high plastic tunnel

The relative humidity values recorded inside the high plastic tunnels showed moderate variation across the experimental period (Figure 2). Minimum humidity fluctuated between 27–40%, with the lowest values observed in late March and early April, and a slight increase toward late April and June. Mean humidity ranged between 58–70%, maintaining relatively stable levels throughout the season, which are characteristic of spring–early summer conditions in protected environments. Maximum humidity remained consistently high, ranging from 85–93%, with the highest values recorded in April and June. These elevated levels are typical of early morning periods in high tunnels and create favourable microclimatic conditions for the development of fungal pathogens such as *Alternaria brassicae* and *Sclerotinia sclerotiorum*. Overall, the combination of moderate mean humidity and persistently high maximum humidity provided suitable conditions for natural disease pressure, allowing for an accurate assessment of the efficacy of the applied protection program.

In the cabbage crop under high plastic tunnel, the following pathogens and pests were identified: *Xanthomonas campestris* (black rot, Figure 3, 4), *Alternaria brassicae* (dark spot of crucifers), *Sclerotinia sclerotiorum* (white rot, Figure 5) and the pests *Brevicoryne brassicae* (cabbage aphid, Figure 6), *Phyllotreta atra* (cabbage flea beetle; Figure 7), *Pieris brassicae* (cabbage white butterfly; Figure 8).

In the cauliflower crop, the pathogens identified were *Xanthomonas campestris* (black rot) and *Alternaria brassicae* (dark spot of crucifers, Figure 9) and the pests *Phyllotreta atra* (cabbage flea beetle, Figure 10), *Pieris brassicae* (cabbage white butterfly), *Plutella maculipennis* (diamondback moth, Figure 11).



Figure 3. Attack of *Xanthomonas campestris* on cabbage



Figure 4. Attack of *Xanthomonas campestris* on cabbage leaf



Figure 5. Attack of *Sclerotinia sclerotiorum* on cabbage



Figure 6. Attack of *Brevicoryne brassicae* on cabbage



Figure 7. Attack of *Phyllotreta atra* on cabbage



Figure 8. Attack of *Pieris brassicae* on cabbage



Figure 9. Attack of *Alternaria brassicae* on cauliflower



Figure 10. Attack of *Phyllotreta atra* on cauliflower



Figure 11. *Plutella maculipennis* - larvae, on cauliflower

For cabbage, the products Amistar 0.1%, Funres 0.3%, Decis Expert 100 EC 0.0075%, Mavrik 2F 0.05%, Flipper 2.0% and Neemex 0.3% provided good protection against the pathogens *Xanthomonas campestris* (E=79.3%), *Alternaria brassicae* (E=78.8%), *Sclerotinia sclerotiorum* (E=78.7%) as well as the pests *Brevicoryne brassicae* (E=88.6%), *Phyllotreta atra* (E=83.5%) and *Pieris brassicae* (E=85.8%) (Table 4).

For cauliflower, the same products ensured high protection against the pathogens *Xanthomonas campestris* (E=91.1%), *Alternaria brassicae* (E=93.6%) and pests *Phyllotreta atra* (E=79.8%), *Pieris brassicae* (E=84.7%), and *Plutella maculipennis* (E =84.0%) (Table 5).

Table 4. Control of damage agents in the cabbage crop under high plastic tunnel (Vidra, 2022)

Damage agents	Degree of attack (%) / hybrid												Average efficacy (%)
	‘Delight Ball F1’			‘Vettel F1’			‘Zarissima RZ F1’			‘Magnus Cresco F1’			
	treated	untreated	E (%)	treated	untreated	E (%)	treated	untreated	E (%)	treated	untreated	E (%)	
<i>X. c.</i>	2.2	10.8	79.6	3.1	21.8	85.8	4.0	17.4	77.0	2.9	11.5	74.8	79.3
<i>A. b.</i>	3.3	14.7	77.5	3.4	12.9	73.6	1.4	11.4	87.7	2.5	10.6	76.4	78.8
<i>S. s.</i>	0.7	3.4	79.4	1.1	3.8	71.0	1.0	6.2	83.9	0.8	4.1	80.5	78.7
<i>B.b.</i>	4.1	31.1	86.8	2.0	33.1	93.9	3.5	26.3	86.7	4.8	36.6	86.9	88.6
<i>P. a.</i>	0.2	2.8	92.9	0.4	3.5	88.6	1.1	4.9	77.5	0.6	2.4	75.0	83.5
<i>P. b.</i>	3.6	20.4	82.3	4.7	31.6	85.1	5.5	42.7	87.1	2.6	23.1	88.7	85.8

X. c. - *Xanthomonas campestris*, *A. b.* - *Alternaria brassicae*, *S. s.* - *Sclerotinia sclerotiorum*, *B. b.* - *Brevicoryne brassicae*, *P. a.* - *Phyllotreta atra*, *P. b.* - *Pieris brassicae*

Table 5. Control of damage agents in the cauliflower crop under high plastic tunnel conditions (Vidra, 2022)

Damage agents	Degree of attack (%) / hybrid									Average efficacy (%)
	'Freedom F1'			'Arienzo RZ F1'			'Venoosa F1'			
	treated	untreated	E (%)	treated	untreated	E (%)	treated	untreated	E (%)	
<i>X. c.</i>	0.4	5.3	92.4	0.5	6.2	91.9	0.8	7.3	89.0	91.1
<i>A. b.</i>	0.2	7.2	97.2	0.7	6.8	89.7	0.4	6.5	93.8	93.6
<i>P. a.</i>	2.7	10.6	74.5	2.5	11.4	78.1	1.6	12.2	86.9	79.8
<i>P. b.</i>	1.8	10.9	83.5	2.1	12.5	83.2	1.5	11.8	87.3	84.7
<i>P. m.</i>	2.9	20.1	85.6	3.3	21.7	84.8	3.8	20.8	81.7	84.0

X. c. - *Xanthomonas campestris*, *A. b.* - *Alternaria brassicae*, *P. a.* - *Phyllotreta atra*,
P. b. - *Pieris brassicae*, *P. m.* - *Plutella maculipennis*

Regarding the yields obtained, on cabbage, they were 9.160 kg/m² for the hybrid 'Delight Ball F1', 8.980 kg/m² for the hybrid 'Vettel F1', 7.840 kg/m² for the hybrid 'Zarissima RZ F1' and 8.050 kg/m² for the hybrid 'Magnus Cresco F1' (treated variants) and respectively 8.530 kg/m² for the 'Delight Ball F1' hybrid, 8.100 kg/m² for the 'Vettel F1' hybrid, 7.090 kg/m² for the 'Zarissima RZ F1' hybrid and 7.140 kg/m² for the 'Magnus Cresco F1' hybrid, for the variants untreated control – V2 (table 6). The 'Delight Ball F1' hybrid had the highest yield (9.160 kg/m²). In the experience with cabbage hybrids, the yield differences obtained in addition to the untreated control variant were very significantly positive.

Referring to the cauliflower yields, they were 6.110 kg/m² for the 'Freedom F1' hybrid, 5.740 kg/m² for the 'Arienzo RZ F1' hybrid and 4.510 kg/m² for the 'Venoosa F1' hybrid (treated variants) and 5.780 kg/m² in the 'Freedom F1' hybrid, 5.260 kg/m² in the 'Arienzo RZ F1' hybrid and 4.120 kg/m² in the 'Venoosa F1' hybrid, respectively the untreated control variants (table 7). The 'Freedom F1' hybrid had the highest yield (6.110 kg/m²). In the experience with cauliflower hybrids, the yield differences obtained in addition to the untreated control variant were significantly and distinctly positive.

Table 6. The obtained yields from the cabbage crop under high plastic tunnel conditions (Vidra, 2022)

Hybrid	kg/m ²		Difference from untreated control (kg/m ²)	% compared to the untreated control	Significance
	treated	untreated			
Delight Ball F1'	9.160	8.530	+0.630	107.4	***
'Vettel F1'	8.980	8.100	+0.880	110.9	***
'Zarissima RZ F1'	7.840	7.090	+0.750	110.6	***
'Magnus Cresco F1'	8.050	7.140	+0.910	112.7	***

LD 5%=0.10; LD 1%=0.14; LD 0,1%=0.20

Table 7. The obtained yields from the cauliflower crop under high plastic tunnel conditions (Vidra, 2022)

Hybrid	kg/m ²		Difference from untreated control (kg/m ²)	% compared to the untreated control	Significance
	treated	untreated			
'Freedom F1'	6.110	5.780	+0.330	105.7	*
'Arienzo RZ F1'	5.740	5.260	+0.480	109.1	**
'Venoosa F1'	4.510	4.120	+0.390	109.5	*

LD 5%=0.31; LD 1%=0.44; LD 0,1%=0.64

CONCLUSIONS

In the cabbage crop, the pathogens *Xanthomonas campestris*, *Alternaria brassicae* and *Sclerotinia sclerotiorum*, together with the pests *Brevicoryne brassicae*, *Phyllotreta atra* and *Pieris brassicae*, were consistently present. In cauliflower, the predominant pathogens were *X. campestris* and *A. brassicae*, while the main pests identified were *Phyllotreta atra*, *Pieris brassicae* and *Plutella maculipennis*.

The integrated sequence of treatments applied in the Treated variant (V1) provided high and consistent protection in both cabbage and cauliflower. Control efficiencies exceeded 78% for all pathogens and 83–89% for pests in cabbage, and reached 89–97% for pathogens and 74–87% for pests in cauliflower.

The positive impact of the protection program was also reflected in yields. All hybrids showed significantly higher production in the Treated variant (V1) compared with the untreated control (V2). The highest yields were obtained for the cabbage hybrid 'Delight Ball F1' (9.160 kg/m²) and the cauliflower hybrid 'Freedom F1' (6.110 kg/m²). Overall, the results demonstrate that the integrated protection program used in this study is highly effective under high plastic tunnel conditions, ensuring strong suppression of key pathogens and pests and leading to significant yield improvements in both cabbage and cauliflower hybrids.

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