

Recovery of herbicide-damaged oilseed rape (*Brassica napus* L.) via biostimulant treatment

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Abstract

Oilseed rape (*Brassica napus* L.) is among the most essential oil crops worldwide. The main limiting factor for its growth and development is the uncontrolled weed infestation. Primary method for weed control is the application of herbicides. If applied improperly they can cause herbicidal phytotoxicity. One phenomenon for this stress is the herbicide drift from one field to another. Therefore, the current study aimed to investigate the response of the conventional oilseed rape variety 'PT 225' to simulated herbicide drift and subsequent ameliorative treatment with plant biostimulant. In this regard, herbicidal drift from a field of Clearfield oilseed rape to the conventional one was imitated. The herbicidal product used was Cleranda SC (17.5 g·L⁻¹ imazamox and 375 g·L⁻¹ metazachlor) used for weed management in Clearfield oilseed rapes. The trial was conducted during 2020/2021 and 2021/2022 on the field of the Agricultural University – Plovdiv, Bulgaria. Treatments of the trial were: 1. Untreated control; 2. 0.40 L·ha⁻¹ (20 % of the rate 2.00 L·ha⁻¹); 3. 0.60 L·ha⁻¹ (30 % of the rate 2.00 L·ha⁻¹); 4. 0.40 L·ha⁻¹ + Amino Expert[®] Impuls (selected biostimulant) – 3.00 L·ha⁻¹, and 5. 0.60 L·ha⁻¹ + Amino Expert Impuls – 3.00 L·ha⁻¹. The levels of phytotoxicity were evaluated by the 9-score scale of European Weed Research Society. Parameters as total leaf chlorophyll content, number of primary branches, plant height at the end of the growing season, seed yield, weight of 1000 seeds, and seed oil content were studied. The damages caused by the herbicidal drift were more severely pronounced at 30 % of the solution fallen to the plants. The ameliorative treatment with the plant biostimulant Amino Expert Impuls helped the plants overcome the herbicidal stress, and the plants showed higher results for the studied indicators.

Key words: herbicide drift, herbicide stress, phytotoxicity, plant biostimulant, weed management.

Introduction

According to the data obtained from the FAO (2019), oilseed rape (*Brassica napus* L.) is the second most important oilseed crop around the globe. The oil production from it is considered to be 20 % of the world's total oil production (Hu et al. 2017). The oilseed rape is a source of high-quality protein for animals and to produce biofuel (Raboanatahiry et al. 2018).

For obtaining high and sustainable yields from the oilseed rape, effective weed management is of great importance (Yanev 2020, Tonev et al. 2021). In the conventional agriculture, weed control in different crops is based mainly on chemical herbicidal treatments. The success of modern herbicides is due to their selective action (Cobb and Reade 2010). However, in some cases, they can cause stress to the crop plants or herbicidal phytotoxicity (Tonev and Vassilev 2011). One of the issues that causes herbicidal toxicity is the herbicide drift (Vischetti et al. 2002, Mueller 2015). This is the movement of herbicidal solutions from the target areas to areas that are not intended to be applied. The main factors leading to herbicide drift are spray particle size, application method, boom height, relative humidity and temperature, wind direction, spray pressure, spray angle, etc. (Dexter 1993). Sufficiently high herbicide doses can kill the weeds as well as the crops.

In contrast, the low rates may have no effect on weeds or crops. The action of a separate herbicide is usually determined by its chemical and physical properties (Streibig 2003). Plants which are tolerant to certain herbicides can detoxify it (Cole 1994, Yuan et al. 2007), but the stressed plants receiving wrong herbicide treatment had reduced nitrogen and increased potassium levels in the leaves (Neshev

2020). The stress factors can lead to flowering interruption and decrease the aboveground biomass weight (Huang and Xiong 2009, Takeno 2016, Nesheva and Bozhkova 2021).

If the plants cannot detoxify the herbicidal ingredient to a sufficient level, different functional impairments may be observed in plants. Most of the time, the herbicidal phytotoxicity is chronic, but in some cases, as drift, it can be lethal for the crop. The damage levels may be determined visually or by different physiological and biochemical indicators (Dayan and Zaccaro 2012, Dayan et al. 2015, Neshev et al. 2022). Plant biostimulants can be applied to improve plant growth and development. According to Calvo et al. (2014), a number of reports show the positive effects of biostimulants on plants exposed to different types of stress (biotic or abiotic).

The potential to recover plants that are damaged by herbicides is based on the levels of the structural-functional impairments. As described by Jablonkai (2013), chronic herbicidal toxicity can be overcome (completely or to some extent) by treatments with different products such as plant biostimulants, foliar fertilisers, growth regulators, herbicide antidotes, etc. The foliar treatment with biostimulant to imazamox-damaged maize plants ameliorates the crop's growth, photosynthesis, and crop productivity (Balabanova et al. 2023). An improvement in winter wheat damaged by imazamox after the application of protein hydrolysate was found by Balabanova (2021). Balabanova et al. (2016) also found that a biostimulant treatment considerably restores the physiological status of IMI-R sunflower plants treated with imazamox. After foliar treatment of oats and winter wheat with the herbicides glyphosate, topramezone, and atrazine, Soltani et al. (2015) recorded a

notable increase in yields obtained from the crops due to biostimulants spraying. Neshev et al. (2020) reported a recovery effect on the pumpkin plants after applying imazamox with the biostimulant as an ameliorative treatment.

The information about the effects of biostimulant application to herbicide-damaged plants is still scarce. Therefore, the current research aimed to study the effect of simulated herbicide drift from Clearfield oilseed rape field to conventional oilseed rape and to evaluate the effect of additionally applied plant biostimulant for medicative treatment to the conventional oilseed rape hybrid.

Materials and Methods

Treatments of the field trial

The field trial included the following treatments:

1. Untreated control;
2. Cleranda SC – $0.40 \text{ L} \cdot \text{ha}^{-1}$ (20 % of the rate $3.00 \text{ L} \cdot \text{ha}^{-1}$);
3. Cleranda SC – $0.60 \text{ L} \cdot \text{ha}^{-1}$ (30 % of the rate $3.00 \text{ L} \cdot \text{ha}^{-1}$);
4. Cleranda SC – $0.40 \text{ L} \cdot \text{ha}^{-1}$ + Amino Expert Impuls – $3.00 \text{ L} \cdot \text{ha}^{-1}$;
5. Cleranda SC – $0.60 \text{ L} \cdot \text{ha}^{-1}$ + Amino Expert Impuls – $3.00 \text{ L} \cdot \text{ha}^{-1}$.

Used herbicidal and biostimulant products

Herbicide: Cleranda® SC ($17.5 \text{ g} \cdot \text{L}^{-1}$ imazamox + $375 \text{ g} \cdot \text{L}^{-1}$ metazachlor) is a herbicidal product that can be applied for control of a range of dicotyledonous and monocotyledonous weeds in Clearfield winter and spring oilseed rape varieties (BASF 2025).

Biostimulant: Amino Expert Impuls (Ecofol AD 2025) (Amino acids – 5.00 %

(free amino acids – 4.43 %); Macroelements: N – 2.53 %; MgO – 0.50 %; SO_3 – 4.02 %; Phytohormones – 0.0003 %; Organic substances and natural adhesives: 73.96 %; Microelements: B – 0.52 %; Cu – 0.39 %; Fe – 0.38 %; Mn – 0.38 %; Mo – 0.08 %; Zn – 0.78 %).

Trial design

The trial was conducted using the randomised block design in three replications with an experimental plot size of 10 m^2 .

The imitation of herbicide drift was performed in crop growth stage three-four leaves unfolded (BBCH 14-15). The biostimulant Amino Expert Impuls was applied four days after the herbicidal drift. The spraying was done with backpack sprayer SOLO model 417 (Solo, Germany) with a spraying solution of $250 \text{ L} \cdot \text{ha}^{-1}$ for both treatments.

The preceding crop for the oilseed rape in the two experimental years was winter wheat. On the trial field, deep ploughing, two times disc harrowing, and two times cultivation before sowing was done. The whole experimental area was fertilised with $250 \text{ kg} \cdot \text{ha}^{-1}$ NPK 15:15:15 and $200 \text{ kg} \cdot \text{ha}^{-1}$ NH_4NO_3 as spring dressing.

The oilseed rape grown in the study was the hybrid PT225 which is one of the most cultivated conventional hybrids with Pioneer® brand in Bulgaria. The hybrid PT225 has excellent pod shattering resistance, maximum yield potential and high oil content and is suitable for late sowing as well. It also has tolerance to economically important diseases and very good cold tolerance.

Studied indicators

Symptoms of herbicidal damages (scores).

The visual scoring of the damages caused by the herbicide drift was assessed by the 9-score visual scale of European Weed Research Society (EWRS) on the 7th, 14th, and 28th days after treatment of the imitation of the herbicide drift. The scores are described below:

1. No effect (healthy plants);
2. Very slight effects; some stunting and yellowing just visible;
3. Slight effects; stunting and yellowing, effects reversible;
4. Substantial chlorosis and/or stunting, most effects probably reversible;
5. Strong chlorosis/stunting; thinning of stand;
6. Increasing severity of damage;
7. Increasing severity of damage;
8. Increasing severity of damage;
9. Total loss of plants and yield.

Number of primary branches per plant (NPB): measurements were taken at the end of the growing season on 25 plants per plot (75 plants in total per treatment).

Plant height (PH, cm): measurements were taken at the end of the growing season on 25 plants per plot (75 plants in total per treatment).

Oilseed rape seed yield (SY): it was recorded by harvesting the entire plot of each treatment. Harvesting was performed using a Wintersteiger field-plot combine (Wintersteiger Group). The data from each plot were recalculated to establish the seed yields per hectare ($\text{t}\cdot\text{ha}^{-1}$).

Weight of 1000 seeds (g): three batches of 1000 seeds for each replication per each variant of the trial were measured. The results for each replication were recalculated by dividing the results of the three batches of 1000 seeds by three to make the average sample for each plot ($3\cdot 3=9$ batches of 1000 seeds per variant) as described by Tonev et al. (2018).

Physiological parameters (in 2021)

Total chlorophyll content ($\text{mg}\cdot\text{m}^{-2}$) at 7, 14 and 28 days after the simulated herbicide drift: a portable chlorophyll meter, model CCM-300 plus was used for measurements. Twenty plants per replication were measured (sixty plants total per treatment).

Seed oil content

The seed oil content (OC) (%) was determined by the Soxhlet method as described by Ivanov and Popov (1994). Three samples per treatment were analysed.

Agrometeorological data

Agrometeorological data during the experiments were obtained from the automatic meteorological station Meteobot® Pro situated by the experimental field. The data is for the average monthly minimum and maximum air temperatures ($^{\circ}\text{C}$) as well as precipitation (mm) for the growing seasons of the oilseed rape during the two years of the study (2020/2021 and 2021/2022).

Statistical analyses of the collected data

Statistical analysis of the obtained results was processed using one-way ANOVA followed by Duncan's Multiple Range Test, implemented in SPSS version 26.

Results and Discussion

Meteorological data

Figures 1 and 2 present the average monthly precipitation and the minimum

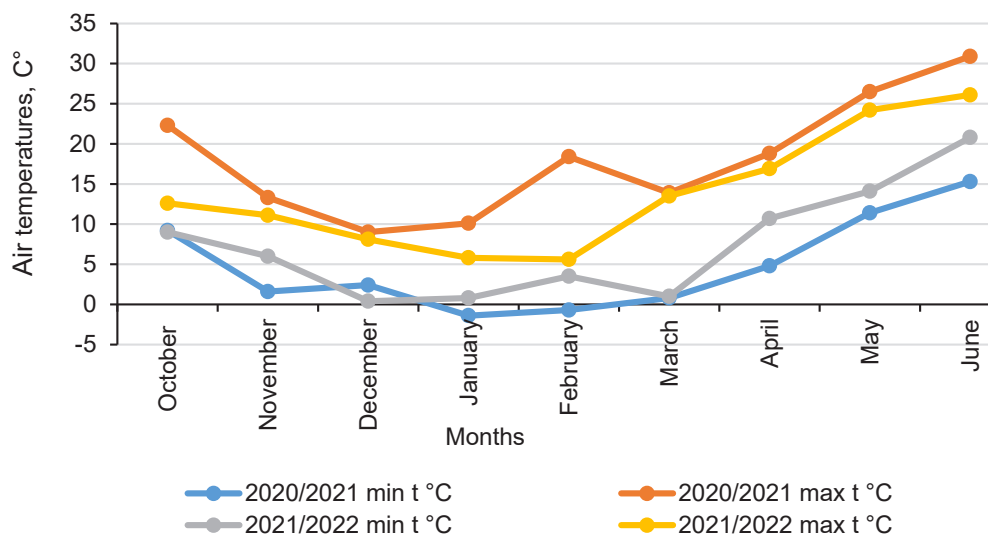


Fig. 1. Average monthly minimum and maximum air temperatures from October to June during the two experimental growing seasons.

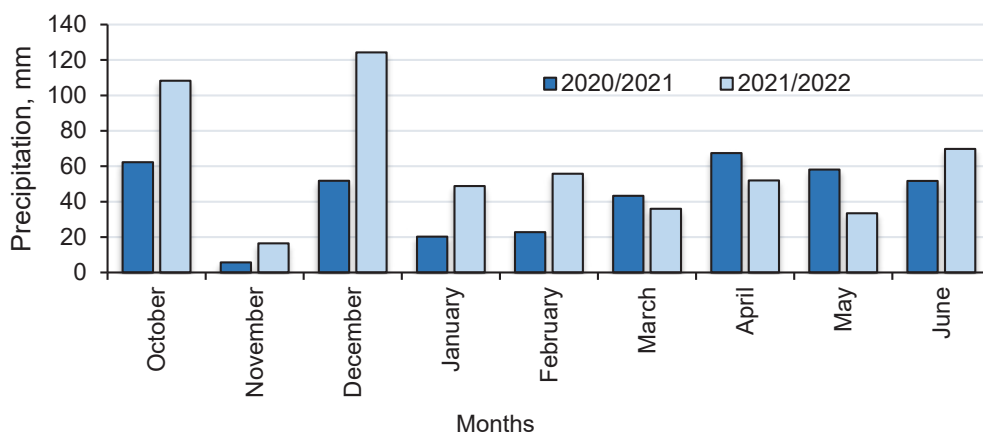


Fig. 2. Average monthly precipitation from October to June during the two experimental growing seasons.

and maximum air temperatures recorded during the oilseed rape growing seasons of 2020/2021 and 2021/2022.

According to the WMO (2010), all pesticides (herbicides, insecticides, fungicides, and rodenticides), as well as growth regulators and fertilisers, require special attention to the meteorological conditions.

In a trial performed by Tonev et al. (2011), the agroecological conditions in the period of herbicide treatment and the first days after application influenced the retention and absorption of foliar herbicides. Before or after the imitation of the herbicide drift, no temperatures that can contribute to the evaluations of the phyto-

toxic symptoms were recorded. If rain falls immediately or during the herbicide spraying, it can wash away any unabsorbed amount of the pesticide. The precipitation amount during imitation of the herbicidal drift in the two experimental years did not affect phytotoxicity and its overcoming by the oilseed rape plants (Fig. 2).

The precipitation was not equally distributed during the oilseed rape growing seasons. As summarised, the total amount of rainfall was higher for the second experimental period (2021/2022), especially in the first part of the growing season. Lower precipitation was recorded in the first research period (2020/2021). The precipitation during the two growing seasons was enough for the plant's growth and development. No water stress was observed during the investigation periods.

The average minimum and maximum air temperatures were different during the two growing seasons of the oilseed rape but suitable for the plants. No extreme values affecting the crop were recorded.

It is summarised that a negative influence of the precipitation and air temperatures was not found.

Symptoms of phytotoxicity caused by the imitation of the herbicide drift

The imazamox that belongs to the imidazolinones is a herbicide that inhibits acetolactate synthase (ALS). This is one of the herbicide-active substances in the herbicidal product Cleranda SC. The visual phytotoxic symptoms from imazamox observed on non-target crops are growth retardation, leaves turgor loss, plants losing their vitality, etc. (Fedke and Duke 2005). In the current experiment, phytotoxicity is considered to be caused by imazamox because the other ingredient is metazachlor. It is known to be selective for the oil-

seed rape (Dimitrova et al. 2014). Neshev et al. (2021b) performed a trial imitating the case of herbicide drift of herbicidal solution intended for weed management in wheat where the higher dose of the herbicide used in the study caused more severe damage to the neighbouring oilseed rape.

In the recent study, these statements were reconfirmed (Fig. 3). On the 7th day after the herbicide drift imitation the visual phytotoxic symptoms caused by the imitation of the herbicide drift were more severely expressed in the plants that received 30 % of 2.00 L·ha⁻¹ registered rate of Cleranda. The plants sprayed with 20 % equivalent of 2.00 L·ha⁻¹ had lower phytotoxic performance. The plants that received a medicative application of the plant biostimulant Amino Expert Impuls recovered to some extent. The plants that received 20 % of Cleranda rate overcame the herbicidal stress caused by the herbicide drift. Their growth and development were improved compared to the plants not receiving biostimulant application. Similar findings from studies worldwide have confirmed the ameliorative application of different biostimulants after herbicide damages in different crops such as oats and winter wheat (Soltani et al. 2015), sunflower (Balabanova et al. 2016), pumpkins (Neshev et al. 2020, 2021a), oilseed rape (Neshev et al. 2021b), and maize (Soltani et al. 2015, Balabanova et al. 2021).

In the second assessment date (14 days after the herbicide drift) the phytotoxicity for treatments 4 Cleranda SC – 0.40 L·ha⁻¹ + Amino Expert Impuls – 3.00 L·ha⁻¹) and 5 (Cleranda SC – 0.60 L·ha⁻¹ + Amino Expert Impuls – 3.00 L·ha⁻¹) decreased to 2. The phytotoxicity at variant 3 (Cleranda SC – 0.60 L·ha⁻¹) decreased to 4, and the phytotoxicity for treatment 2 (Cleranda SC – 0.40 L·ha⁻¹) was diminished to 3.

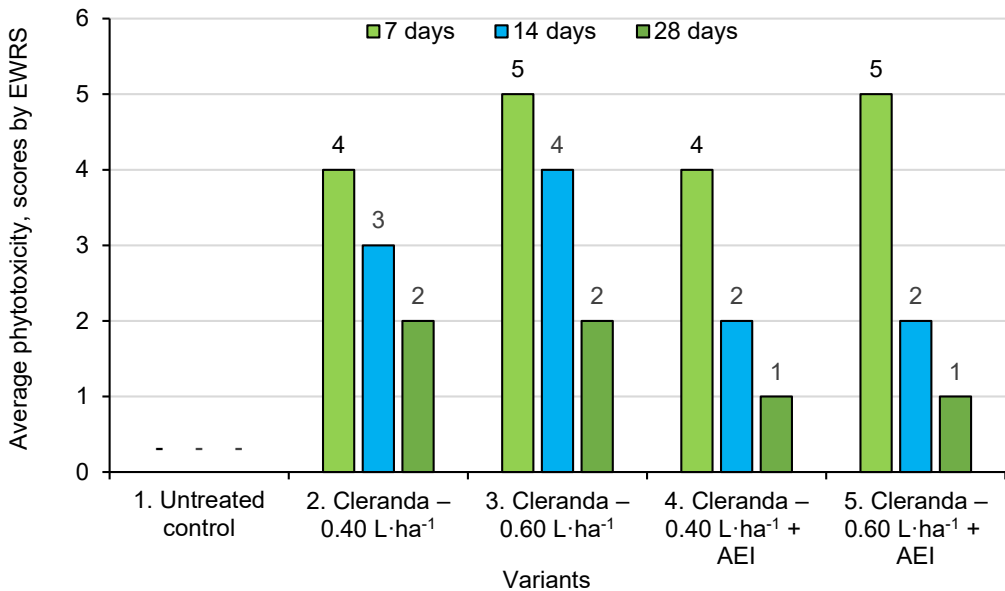


Fig. 3. Average phytotoxicity scores according to EWRS 9-point scale.

On the last evaluation date (28 days after the herbicide drift), the plants treated with Amino Expert Impuls had a phytotoxicity score of 1, which indicates that the application of the biostimulant improves the status of the plants of the experiment. In the plants without ameliorative biostimulant treatment, the phytotoxicity on the 28th day was with a score of 2, and a very weak suppression of the rape plants was still observed.

Physiological parameters: Total chlorophyll

The total chlorophyll content differed between the treatments (Table 1). Sharma et al. (2018) found that the application of pesticides can cause oxidative stress to plants. This oxidative stress can result in chlorophyll degradation that is reducing the plants' photosynthetic efficiency (Xia et al. 2006, Badr et al. 2013, Sharma et al.

Table 1. Total chlorophyll content (mg·m⁻²) in 2021.

Treatments	Days after the herbicide drift		
	7	14	28
1. Untreated control	375 a	414 a	432 a
2. Cleranda SC – 0.40 L·ha ⁻¹	212 c	259 c	318 c
3. Cleranda SC – 0.60 L·ha ⁻¹	154 d	210 d	224 d
4. Cleranda SC – 0.40 L·ha ⁻¹ + Amino Expert Impuls – 3.00 L·ha ⁻¹	314 b	354 b	397 b
5. Cleranda SC – 0.60 L·ha ⁻¹ + Amino Expert Impuls – 3.00 L·ha ⁻¹	194 d	218 d	246 d

Note: Means followed by different letters differ significantly according to Duncan's Multiple Range Test ($p < 0.05$).

2015, Varshney et al. 2015).

Compared to control there was a significant decrease of the total chlorophyll content because of the herbicidal drift. When the oilseed rape plants were stressed to a greater degree (after receiving 30 % of the 2.00 L·ha⁻¹ registered rate of Cleranda) the total chlorophyll in the leaves was diminished. Higher total chlorophyll content was measured in the leaves decreased significantly compared to control. Higher total chlorophyll content was measured in the leaves of the plants that had ameliorative application of biostimulant. The data obtained correspond with results recorded by Neshev et al. (2021b), where an improvement effect of plant biostimulant regarding the plastid pigments content was found.

The results for the content of total chlorophyll in the leaves showed an increase in the chlorophyll content over time in all treatments.

On all measurement dates, the highest content of total chlorophyll in oilseed rape leaves was found in the untreated control – 375, 414 and 432 mg·m⁻² (7, 14 and 28 days after treatment, respectively).

On the 7th day after the imitation of the herbicide drift, the lowest values for the indicator were found in variant 3 – 154 mg·m⁻². Seven days after spraying in variant 2, the content of total chlorophyll was slightly higher, at 212 mg·m⁻². An increase in the chlorophyll content in the leaves was found during the subsequent measurement dates.

A positive influence of the medicinal treatment with the biostimulant Amino Expert Impulse was reported regarding the content of total chlorophyll in leaves. The positive effect was higher in the variant treated with 20 % of the herbicide Cleranda, where the content of total chlorophyll in the leaves was 314 mg·m⁻² on the 7th

day after the herbicide drift, and the increase in the result was significant.

Number of primary branches per plant and plant height

NPB is presented in Table 2. The highest number of branches per plant were counted for the untreated control – 7.65 on average across the study period. The lowest results for plants in which herbicide drift was simulated with 20 and 30 % of the rate 2.00 L·ha⁻¹ were reported – 3.85 and 3.60 branches per plant. For the treatments where a remedial biostimulant application was sprayed, the plants were found to increase the number of branches to some extent.

In research findings, the reports of Varshney et al. (2015), Neshev et al. (2020), and Marques et al. (2021) concerning the diminishing of the growth parameters of plants that were exposed to herbicidal stress are reconfirmed.

The indicators of NPB per plant and PH at the end of the growing season were lower when compared to the untreated control plants. A higher decrease was obtained for the plants that received 30 % of the 2.00 L·ha⁻¹ registered rate of Cleranda (Treatment 3). As found by other scientists, the growth traits are enhanced after the application of plant biostimulant for ameliorative treatment (Calvo et al. 2014; Constantin et al. 2016; Neshev et al. 2021b, 2022; Balabanova et al. 2023).

Oilseed rape seed yield

It was found that herbicide drift and the subsequent herbicidal stress can cause a severe yield decrease (Schroeder et al. 1983, Deeds et al. 2006, Roider et al. 2008, Webster et al. 2016, Neshev et al. 2021b, Balabanova et al. 2023).

Table 2. Number of primary branches and plant height (cm) at the end of the growing season.

Treatments	Experimental seasons		Average
	2020/2021	2021/2022	
Number of primary branches per plant			
1. Untreated control	7.20 a	8.10 a	7.65
2. Cleranda SC – 0.40 L·ha ⁻¹	4.80 b	6.30 b	5.55
3. Cleranda SC – 0.60 L·ha ⁻¹	3.60 d	4.10 c	3.85
4. Cleranda SC – 0.40 L·ha ⁻¹ + Amino Expert Impuls – 3.00 L·ha ⁻¹	5.50 b	5.90 b	5.70
5. Cleranda SC – 0.60 L·ha ⁻¹ + Amino Expert Impuls – 3.00 L·ha ⁻¹	4.00 c	4.40 c	4.20
Plant height, cm			
1. Untreated control	1.55 a	1.63 a	1.59
2. Cleranda SC – 0.40 L·ha ⁻¹	1.08 c	1.16 b	1.12
3. Cleranda SC – 0.60 L·ha ⁻¹	0.95 d	0.99 c	0.97
4. Cleranda SC – 0.40 L·ha ⁻¹ + Amino Expert Impuls – 3.00 L·ha ⁻¹	1.18 b	1.27 b	1.23
5. Cleranda SC – 0.60 L·ha ⁻¹ + Amino Expert Impuls – 3.00 L·ha ⁻¹	1.11 c	0.97 c	1.04

Note: Means followed by different letters differ significantly according to Duncan's Multiple Range Test ($p < 0.05$).

In our study the highest SY was recorded in the untreated control (2.68 t·ha⁻¹). The treatments in which the biostimulant treatment was applied increased their yields compared to the treatments that received 20 and 30 % of 2.00 L·ha⁻¹ of Cleranda herbicide. After the imitation of the herbicidal drift the obtained seed yields for these treatments were 2.24 and

1.50 t·ha⁻¹ respectively average for both experimental years (Table 3). The seed yields for the treatments where only imitation of herbicide drift was carried out were significantly lower compared to the control – 2.02 t·ha⁻¹ for the 20 % and 1.24 t·ha⁻¹ for the 30 %.

The yields for the plants that received 20 and 30 % of the herbicidal rate

Table 3. Oilseed rape seed yield (SY), t ha⁻¹.

Treatments	Experimental seasons		Average
	2020/2021	2021/2022	
1. Untreated control	2.47 a	2.88 a	2.68
2. Cleranda SC – 0.40 L·ha ⁻¹	1.88 b	2.15 b	2.02
3. Cleranda SC – 0.60 L·ha ⁻¹	1.09 d	1.39 c	1.24
4. Cleranda SC – 0.40 L·ha ⁻¹ + Amino Expert Impuls – 3.00 L·ha ⁻¹	2.11 b	2.37 b	2.24
5. Cleranda SC – 0.60 L·ha ⁻¹ + Amino Expert Impuls – 3.00 L·ha ⁻¹	1.51 c	1.48 c	1.50

Note: Means followed by different letters differ significantly according to Duncan's Multiple Range Test ($p < 0.05$).

2.00 L·ha⁻¹ of Cleranda were lower. With the application of biostimulants an increase in crop productivity was recorded (Panfili et al. 2019; Neshev et al. 2020, 2021a, 2021b, 2022; Balabanova et al. 2023). The findings correspond with the data from the recent study. The plants that received ameliorative plant biostimulant treatment showed seed yield increase in comparison to the variants where no spraying of ameliorative product was done.

Weight of 1000 seeds

According to Georgiev et al. (2014), the parameter weight of 1000 seeds is of great importance for the crops' productivity. The weight of 1000 seeds of the oilseed rape differed among the treatments as well.

The untreated control had the highest results for the indicator (Table 4). It was found that herbicidal stress can decrease the weight of 1000 seeds of different crops (Mitkov et al. 2019; Neshev et al. 2021b, 2022). The mentioned finding is confirmed in the present research as well. The plants that received inappropriate herbicidal solution by the herbicide drift had the lowest weight of 1000 seeds, and after the

medicative biostimulant application, the indicator was enhanced when compared to the plants treated with the wrong herbicide only.

As with all the investigated indicators, and with this indicator, the highest results were in the untreated control – 4.25 g average for the period. The weight of 1000 seeds of the plants treated with the plant biostimulant was 3.93 and 3.41 g, respectively, for the 20 and 30 % of the herbicidal product Cleranda. The lowest results for the indicator for the plants that received 30 % of the 2.00 L·ha⁻¹ rate of the herbicide – 3.21 g.

Seed oil content

As for all other evaluated parameters, differences between the treatments were found for the SO content (Table 5).

In the seeds of the untreated control plants, the highest SO was measured, with an average of 49.8 % for the trial period. After the analyses, the lowest SO for treatment 3 was recorded – 43.3 %. After the ameliorative biostimulant application, a slight increase in SO for treatments 4 and 5 was found – 47.0 and 43.9 % average for the research conditions.

Table 4. Weight of 1000 seeds, g.

Treatments	Experimental seasons		Average
	2020/2021	2021/2022	
1. Untreated control	4.14 a	4.34 a	4.25
2. Cleranda SC – 0.40 L·ha ⁻¹	3.64 b	3.73 b	3.69
3. Cleranda SC – 0.60 L·ha ⁻¹	3.25 c	3.17 d	3.21
4. Cleranda SC – 0.40 L·ha ⁻¹ + Amino Expert Impuls – 3.00 L·ha ⁻¹	4.04 ab	3.81 b	3.93
5. Cleranda SC – 0.60 L·ha ⁻¹ + Amino Expert Impuls – 3.00 L·ha ⁻¹	3.51 b	3.30 c	3.41

Note: Means followed by different letters differ significantly according to Duncan's Multiple Range Test ($p < 0.05$).

Table 5. Seed oil content, %.

Treatments	Experimental seasons		Average
	2020/2021	2021/2022	
1. Untreated control	48.5 a	51.0 a	49.8
2. Cleranda SC – 0.40 L·ha ⁻¹	44.4 c	46.7 b	45.6
3. Cleranda SC – 0.60 L·ha ⁻¹	42.6 e	44.0 c	43.3
4. Cleranda SC – 0.40 L·ha ⁻¹ + Amino Expert Impuls – 3.00 L·ha ⁻¹	46.7 b	47.3 b	47.0
5. Cleranda SC – 0.60 L·ha ⁻¹ + Amino Expert Impuls – 3.00 L·ha ⁻¹	43.3 d	44.5 c	43.9

Note: Means followed by different letters differ significantly according to Duncan's Multiple Range Test ($p < 0.05$).

Conclusion

Herbicide drift induces phytotoxic symptoms in the conventional oilseed rape hybrid PT 225, and the damage is more severely pronounced at 30 % of the high registered rate (2.00 L·ha⁻¹) of the herbicidal product Cleranda. The plants that received a medical biostimulant treatment recover faster and show higher results for the studied parameters such as plant height, number of branches, seed yield, weight of 1000 seeds, and seed oil content. The increased values of the physiological indicator total chlorophyll in the leaves confirmed the improving effect of the application of the plant biostimulator Amino Expert Impulse.

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