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Efficacy of plant extracts against adults of the pollen beetle (*Brassicogethes / Meligethes aeneus* F.) and the red cabbage bug (*Eurydema ornata* L.)

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Abstract

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Despite its many advantages as a crop, oilseed rape is host to a large number of pests that can cause economically significant losses.

The pollen beetle (*Brassicogethes/Meligethes aeneus* F.) is one of the species of economic importance as an pest of oilseed rape during its mass multiplication. In some years, the red cabbage bug (*Eurydema ornata* L.) is also found en masse.

The repeated use of insecticides used in oilseed rape agrocenosis, often leads to the development of resistance, the destruction of beneficial entomofauna and pollinators, which is why alternative means are sought.

In this regard, the efficacy of plant extracts of ginger (*Zingiber officinale* L.), peppermint (*Mentha piperita* L.) and nettle (*Urtica dioica* L.) was tested against the pollen beetle (*Brassicogethes/Meligethes aeneus* F.) and the red cabbage bug (*Eurydema ornata* L.).

The study was carried out under laboratory conditions at the Agricultural University-Plovdiv. The attempt was made in four variants and three repetitions. The processing of the obtained data was carried out with a package of statistical programs Statistika 7 V.

Tested plant extracts affect the vitality of pests, which is due to species-specific alkaloids. In the case of the pollen beetle, the highest efficacy was reported for nettle and ginger – 99.7%, and for the red cabbage bug, mint and nettle – 83%. All plant extracts increase their efficacy gradually.

Keywords: plant extract; *Zingiber officinale* L.; *Mentha piperita* L.; *Urtica dioica* L.; *Brassicogethes/Meligethes aeneus* F.; *Eurydema ornata* L.

Introduction

Oilseed rape cultivation is accompanied by a number of plant protection problems, because it is attacked by many pests. Some of them are strictly specialized, while others have a wider nutritional plasticity, which makes them potential pests of crop plants grown in the neighborhood.

Oilseed rape is attacked by 37 insect species, of which 22 species damage the leaves, 12 the stems, and 11 the podsand seeds (Zheng et al., 2020).

In Europe, the pollen beetle *Brassicogethes aeneus* F. (*Meligethes aeneus*) is import pest of oilseed rape (*Brassica napus* L.) (Willow et al., 2020). According to them, in individual years the losses from it can reach 80-100%.

The pollen beetle becomes active in the spring, when the average day-night temperatures reach 15°C and the flower buds of the oilseed rape are formed. The beetles concentrate on them and feed on the buds. Damaged flower buds wilt, dry and fall off. The extent of damage depends on weather conditions. In a cool spring, damage is greater and often reaches 50–60%.

The red cabbage bug first occurs on the cruciferous weed vegetation, and later moves to the cultivated crucifers in the field. Adults and larvae suck sap from young tender parts of cruciferous plants, especially young leaves, leaf and flower stalks and pods. In case of mass occurrence, the plants die.

The massuse of insecticides to combat the pests of oilseed rape has a number of negative impacts on the environment, the destruction of bees, beneficial species, the emergence of resistance in insects to someplant protection products, which neces sitates the search for new alternatives to control pests.

In recent years, the pollen beetle (*M. aeneus*) and red cabbage bug (*E. ornata* L.) have shown resistance to the insecticides used in practice, resulting in the search for alternative plant protection methods and control agents that are safe for the bees.

Secondary compounds from plants including alkaloids, terpenoids, phenolics, and flavonoids can affect insects in several ways. They may disrupt major metabolic pathways and cause rapid death, act as attractants, deterrents, phago-stimulants antifeedants or modify oviposition. They may also slow down or accelerate development (Smet et al., 1986; Houghton, 1996).

Plant insecticides have been used to fight pests for centuries (Isman, 2006). Since majority of plant insecticides are biodegradable, it leads to revival of growing interest in the use of either plant extracts or essential oils. More than 1500 species of plants have been reported to have insecticidal value, and many more exist.

Kumar et al. (2011) reported insecticidal properties of various *Mentha species*. Kalemba and Synowiec (2020) considered the agrobiological (insecticide and herbicide) activity of menthol present in *M. arvensis* and *M. piperita.*

Pavela (2011) studied the insecticidal activity of essential oils from 9 plant species: *Carum carvi* L., *Cinnamomumos mophloeum* Kaneh., *Citrus aurantium* L., *Foeniculum vulgare* Mill., *Lavandula angustifolia* L., *Mentha arvensis* L., *Nepeta cataria* L., *Ocimum basilicum* L. and *Thymus vulgaris* L. against adult forms of pollen beetle. Of these, the plant extracts of caraway (*Carum sarvi* L.) and thyme (*Thymus vulgaris* L.) showed the highest efficacy 65.6–63.8%. At the same time, more than 50% of oilseed rape buds burst into blossom, showing its protective role against *M.* a*eneus.*

Escobar-Garcia et al. (2024) tested 7 plant species in the form of aqueous botanical control of the diamondback moth, *Plutella xylostella*. There was a difference between the treatments, highlighting the decoction of *Couroupita guianensis* – 39%, followed by infusions of *Codiaeum variegatum* and *Ruta graveolens,* both with a 29% efficiency rate.

The *Urtica dioica* L. can be used as pest control. The most important characteristic of this plant is the stinging hairs that are spread on it, which cause allergies when approached or touched. Therefore, it is considered a repellent plant for insects (Maričić et al., 2021). Another important property that makes this plant useful for pest control is its content of phenolic antioxidants in its tissues. (Esposito et al., 2019).

In Iraq, Al-Joary et al. (2021) reported that the nettle plant powder achieved a 30.46% repellency against the red flour beetle *Tribolium confusum.* In controlling the whitefly B*emisia tabaci*, the alcoholic extract of the nettle plant achieved a killing rate of 68.74% for whitefly nymphs and adults (Al-Bujari and Al-Jamil, 2021).

Ghani (2021) found in his study that the use of plant powders of nettle, cinnamon, and oleander achieved good and varying rates of repellency against larvae of the greater wax moth. Active substances found in the stinging nettle plant are terpenoids, alkaloids, saponins, coumarin, and phenols. These compounds are found in different parts of the plant, such as the roots, stems, flowers, and fruits. They can be used as natural insecticides, because they are inexpensive, safe, and environmentally friendly (Ratnasekera and Rajapakse, 2009; Thorayia et al., 2012; Al-Joary et al., 2021).

Keosaeng et al. (2022) tested of the extracts of *Zingiber officinale* three insect pest species; *S. exigua, S. litura* and *S. frugiperda.*

Several plant extracts have been used as potential insect pest control agents due to their content of different substances and their effect as insecticides or repellents (Salhi et al., 2019; Hamdouch et al. 2022; Naser AL-Isawi, 2022; Kadhim and Younis, 2023).

Zingiber officinale components, which have displayed insecticidal, anti-feedant, growth regulating and repellent activity against many insect pests (Abdulhay and Yonius, 2019). Previous studies investigated the insecticidal effects of *Z. officinale* against red flour beetle, *Tribolium castaneum*, Mediterranean flour moth, *Ephestia kuehniella* and Indian meal moth, *Plodia interpunctella* (Maedeh et al., 2012), *Oryzaephilus surinamensis* and *Oryzaephilus mercator* (Amiri et al., 2016).

According to a number of authors (Pavela, 2011; Mauchline et al. 2005, 2013; Dorn et al. 2014), lavender (*Lavandula* a*ngustifolia* Mill.) essential oil exhibits different efficacy against *B. aeneus*. The compounds linalool and linalylacetate contained in lavender act as repellents against *B. aeneus* (Mauchline et al., 2008).

In this regard, the aim of the present study was to determine the insecticidal activity of some plant extracts against the pollen beetle (*Brassicogethes/Meligethes aeneus* F.) and the red cabbage bug (*Eurydema ornata* L.).

Material and Methods

The studies were carried out under laboratory conditions at the Agricultural University-Plovdiv, at 25 ± 2°C and 65 ± 5 % relative humidity. The efficacy of plant extracts of ginger (*Zingiber officinale* L.), peppermint (*Mentha piperita* L.) and nettle (*Urtica dioica* L.) was tested against the adult of the pollen beetle (*Brassicogethes/Meligethes aeneus* F.) and the red cabbage bug (*Eurydema ornata* L.).

Leaves, stalks of nettle, peppermint and ginger roots are dried on filter paper. After that, the plant parts were ground with a grinder and stored in glass jars. From each plant species, 50 g of dry material was taken, then was soaked in one liter of water and left for 24 hours in the dark. The liquid is filtered to remove solids 20 ml of each extract was taken and dissolved in 100 ml of distilled water. It was treated with the thus obtained mixture.

Adults of the pollen beetle and red cabbage bug were collected from oil seed raps crops. After that, 10 insects of each species were placed in Petri dishes with filter paper and oilseed raps flowers, and treated with the above-mentioned plant extracts.

The experiment was carried out in four variants and three repetitions: Variant I – control, Variant II – treatment with plant extract of ginger; Variant III – treatment with plant extract of peppermint and Variant IV – treatment with plant extract of nettle.

Each variant is treated with the respective plant extract. The control was treated with water.

The readings were performed after 24 hours, on the 3rd, 5th and 7th day after the treatment.

The efficiency was calculated according to the Henderson-Tilton formula:

$$E\% = \left(1 - \frac{TaxCb}{TbxCa}\right).100$$

where:

Ta – number of live ones in the version after spraying;
Tb – number of live ones in the version before spraying;
Ca – number alive in control after spraying;
Cb – number alive in the control before spraying.

The processing of the obtained data was carried out with a package of statistical programs Statistika 7 V.

Results and Discussion

From the data in Table 1, it is evident that the tested plant extracts definitely affect the vigor of the pollen beetle. At the 24th hour after the treatment, the highest efficacy was recorded with peppermint – 77%, followed by ginger -73% and nettle – 70%. There is no proven statistical difference between the action of the individual extracts (Figure 1).

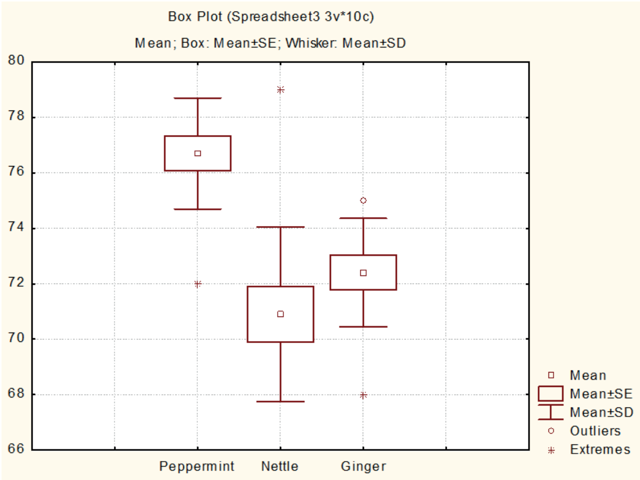

Fig. 1. Efficacy at 24 hours after treatment (%)
Source: Authors' own elaboration

Table 1. Comparison of mean values at 24 hours after treatment

T-test for Independent Samples (*B. aeneus* 24 h)					
	Mean 1	Mean 2	t-value	df	p
Control vs. 24 J	10.00000	2.666667	22.00000	4	0.000025
Control vs. 24 P	10.00000	2.333333	23.00000	4	0.000021
Controlvs. 24 N	10.00000	3.000000	4.58258	4	0.010164
24 J vs. 24 P	2.666667	2.333333	0.707107	4	0.518519
24 J vs. 24 N	2.666667	3.000000	-0.213201	4	0.841596
24 P vs. 24 N	2.333333	3.000000	-0.426401	4	0.691761

Source: Authors' own elaboration

On the third day, a similar situation was observed, with the efficacy gradually increasing. For peppermint it is 83%, for ginger – 80%, and for nettle – 77% (Table 2, Figure 2).

On the 5th day after treatment, the efficacy began to gradually increase to reach 93% for peppermint, 87% for ginger and 80% for nettle (Table 3, Figure 3).

The tested plant extracts showed an initial toxic effect, which gradually increased and on the seventh day it was 93.4% for peppermint and 99.7% for nettle and ginger. (Table 4, Figure 4).

The plant extracts tested on the red cabbage bug on the first day after treatment showed little efficacy. It varies from 33 to 37% for peppermint, nettle and ginger, respectively. There is no proven statistical difference between the individual variants (Table 5, Figure 5).

On the third day, the efficacy increases, approaching 50% with ginger and 40% with peppermint. Only nettles retain the low values of 33% (Table 6, Figure 6).

On the fifth day, the efficacy begins to gradually increase to reach 67% for ginger and 57% for peppermint. The picture is interesting, with the nettle, the efficacy is almost twice as high compared to the third day – 63% (Table 7, Figure 7).

Table 2. Comparison of mean values at day 3 after treatment

T-test for Independent Samples (*B. aeneus* 3 day)					
	Mean 1	Mean 2	t-value	df	p
Control vs. 3 J	10.00000	2.000000	13.85641	4	0.000157
Controlvs. 3 P	10.00000	1.666667	25.00000	4	0.000015
Control vs. 3 N	10.00000	2.333333	23.00000	4	0.000021
3 J vs. 3 P	2.000000	1.666667	0.500000	4	0.643330
3 J vs. 3 N	2.000000	2.333333	-0.500000	4	0.643330
3 P vs. 3 N	1.666667	2.333333	-1.41421	4	0.230200

Source: Authors' own elaboration

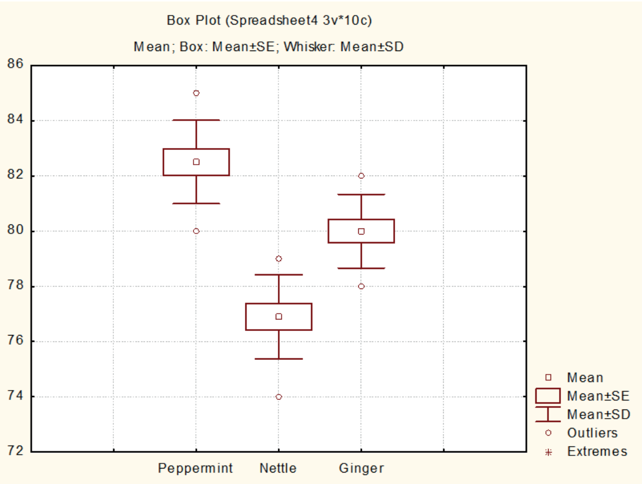

Fig. 2. Efficacy at day 3 after treatment (%)
Source: Authors' own elaboration

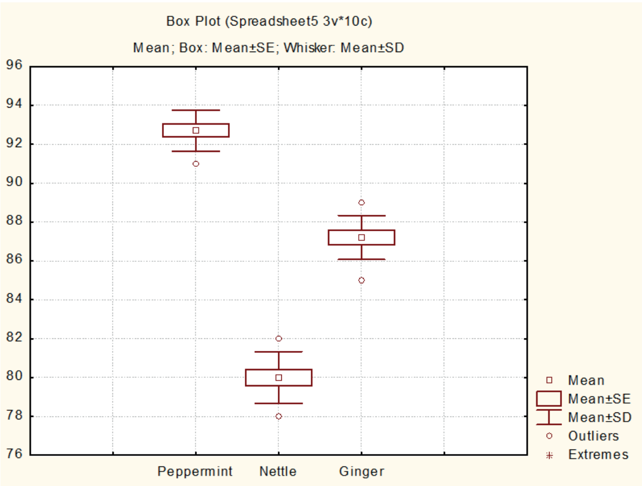

Fig. 3. Efficacy at day 5 after treatment (%)
Source: Authors' own elaboration

Table 3. Comparison of mean values at day 5 after treatment

T-test for Independent Samples (*B. aeneus* 5 day)					
	Mean 1	Mean 2	t-value	df	p
Controlvs. 5 J	10.00000	1.333333	26.00000	4	0.000013
Controlvs. 5 P	10.00000	0.666667	28.00000	4	0.000010
Controlvs. 5 N	10.00000	2.000000	13.85641	4	0.000157
5 J vs. 5 P	1.333333	0.666667	1.41421	4	0.230200
5 J vs. 5 N	1.333333	2.000000	-1.00000	4	0.373901
5 P vs. 5 N	0.666667	2.000000	-2.00000	4	0.116117

Source: Authors' own elaboration

Table 4. Comparison of mean values at day 7 after treatment

T-test for Independent Samples (*B. aeneus* 7 day)					
	Mean 1	Mean 2	t-value	df	p
Control vs. 7 J	10.00000	0.033333	299.0000	4	0.000000
Controlvs. 7 P	10.00000	0.033333	299.0000	4	0.000000
Control vs. 7 N	10.00000	0.666667	28.0000	4	0.000010
7 J vs. 7 P	0.033333	0.033333	0.00000	4	1.000000
7 J vs. 7 N	0.033333	0.666667	-1.89057	4	0.131664
7 P vs. 7 N	0.033333	0.666667	-1.89057	4	0.131664

Source: Authors' own elaboration

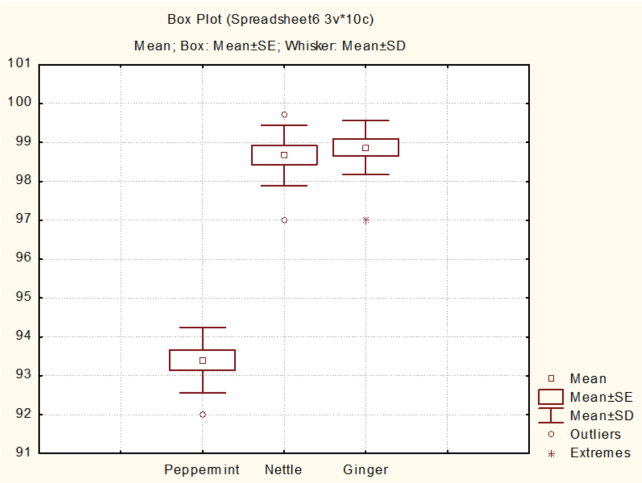

Fig. 4. Efficacy at day 7 after treatment (%)
Source: Authors' own elaboration

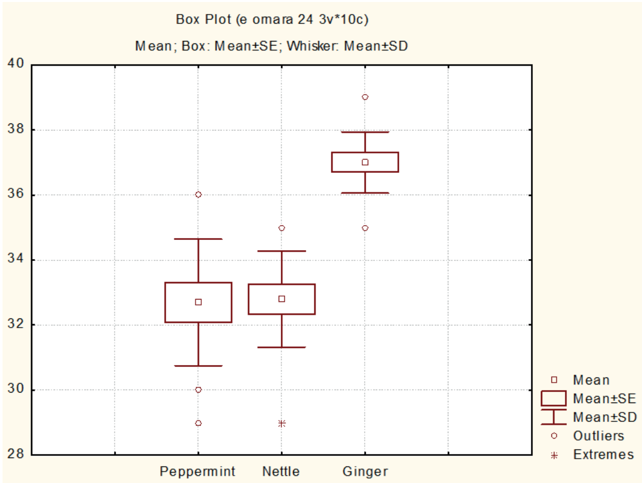

Fig. 5. Efficacy at 24 hours after treatment (%)
Source: Authors' own elaboration

Table 5. Comparison of mean values at 24 hours after treatment

T-test for Independent Samples (*E. ornata* 24 h)					
	Mean 1	Mean 2	t-value	df	p
Control vs. 24 J	10.00000	6.333333	5.500000	4	0.005328
Control vs. 24 P	10.00000	6.666667	2.773501	4	0.050151
Control vs. 24 N	10.00000	6.666667	3.779645	4	0.019442
24 J vs. 24 P	6.333333	6.666667	-0.242536	4	0.820294
24 J vs. 24 N	6.333333	6.666667	-0.301511	4	0.778050
24 P vs. 24 N	6.666667	6.666667	0.00	4	1.000000

Source: Authors' own elaboration

On the seventh day, the efficacy for peppermint and nettle reaches 83%, and for ginger 80% (Table 8, Figure 8).

The efficacy of the tested plant extracts for the control of the pollen beetle and the red cabbage bug increased significantly with time, which is consistent with the data of other authors (Ogendo et al. 2008; Maedeh et al. 2012; Atta et al. 2020). The high toxicity exhibited by individual plant species is probably due to the specific alkaloids they contain.

Z. officinale has been reported to contain a sesquiterpene hydrocarbon; and pungent odor appears to be responsible for its toxic effect on insect pests (Atta et al., 2020). Insecticidal, repellent and fumigant properties of monoterpenes, the main component of essential oils, have been reported against stored-product insects (Khani and Basavand, 2012). The main monoterpene constituents, such as 1,8-cineole, α-pinene, myrcene, and ar-curcumene, were previously reported as toxic and repellent agents against some insect pests (Maedeh et al. 2012).

Table 6. Comparison of mean values on day 3 after treatment

T-test for Independent Samples (*E. ornata* 3 day)					
	Mean 1	Mean 2	t-value	df	P
Control vs. 3 J	10.00000	5.000000	4.33013	4	0.012348
Control vs. 3 P	10.00000	6.000000	6.92820	4	0.002278
Control vs. 3 N	10.00000	6.666667	10.00000	4	0.000562
3 J vs. 3 P	5.000000	6.000000	-0.77460	4	0.481817
3 J vs. 3 N	5.000000	6.666667	-1.38675	4	0.237796
3 P vs. 3 N	6.000000	6.666667	-1.00000	4	0.373901

Source: Authors' own elaboration

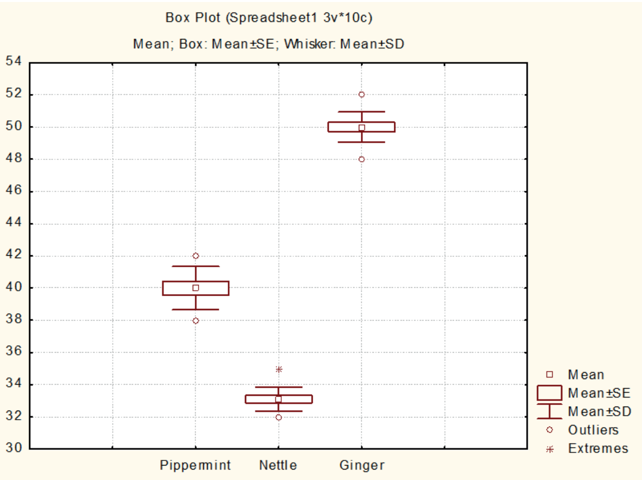

Fig. 6. Efficacy at day 3 after reatment (%)
Source: Authors' own elaboration

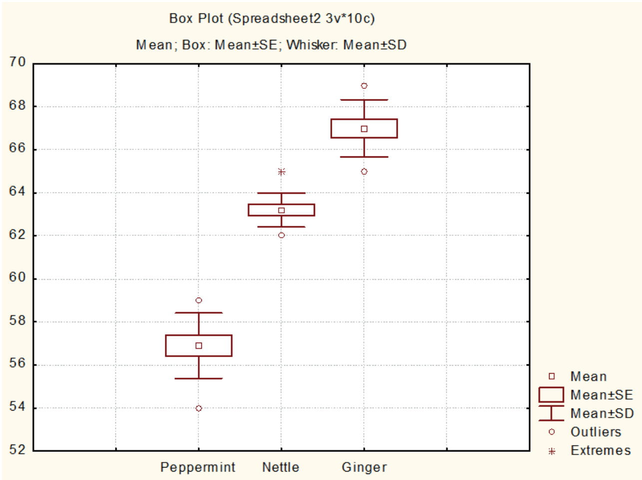

Fig. 7. Efficacy at day 5 after treatment (%)
Source: Authors' own elaboration

Table 7. Comparison of mean values on day 5 after treatment

T-test for Independent Samples (*E. ornata* 5 day)					
	Mean 1	Mean 2	t-value	df	p
Control vs. 5 J	10.00000	3.333333	10.00000	4	0.000562
Control vs. 5 P	10.00000	4.333333	17.00000	4	0.000070
Control vs. 5 N	10.00000	3.666667	19.00000	4	0.000045
5 J vs. 5 P	3.333333	4.333333	-1.34164	4	0.250815
5 J vs. 5 N	3.333333	3.666667	-0.44721	4	0.677869
5 P vs. 5 N	4.333333	3.666667	1.414214	4	0.230200

Source: Authors' own elaboration

The toxicity of peppermint is related to the content of menthol (monoterpene type) (over 50%), menthofuran, menthone (about 20%), menthol esters – menthol acetate and valerate (about 5%), phellandrene, pinene, cineole, menthofuran, piperitone , jasmon, tannins (6–12%), flavonoids (luteolin, apigenin, diosmetin), as well as mustard, phenolic acids and mineral salts (İşcan et al., 2002; Kumar et al., 2011).

Nettle is used as a means of combating pests, which is associated with the phenolics and antioxidants it contains (González-Macedo et al., 2021; Mahmoud and Ghani, 2024).

According to Sehari et al. (2019), the toxicity of nettle is explained by the content of aromatic rings, alkenes, aliphatic fluoro, alcohols, ethers, carboxlic acids, esters, nitro compounds, hydrogen bonded alcohols and phenols. Active substances found in the stinging nettle plant are (terpenoids, alkaloids, saponins, coumarin, and phenols). These compounds are found in different parts of the plant, such as the

Table 8. Comparison of mean values at day 7 after treatment

T-test for Independent Samples (*E. ornate* 7 day)					
	Mean 1	Mean 2	t-value	df	p
Control vs. 7 J	10.00000	2.000000	13.85641	4	0.000157
Control vs. 7 P	10.00000	1.666667	12.50000	4	0.000236
Control vs. 7 N	10.00000	1.666667	6.93375	4	0.002272
7 J vs. 7 P	2.000000	1.666667	0.377964	4	0.724659
7 J vs. 7 N	2.000000	1.666667	0.250000	4	0.814902
7 P vs. 7 N	1.666667	1.666667	-0.000000	4	1.000000

Source: Authors' own elaboration

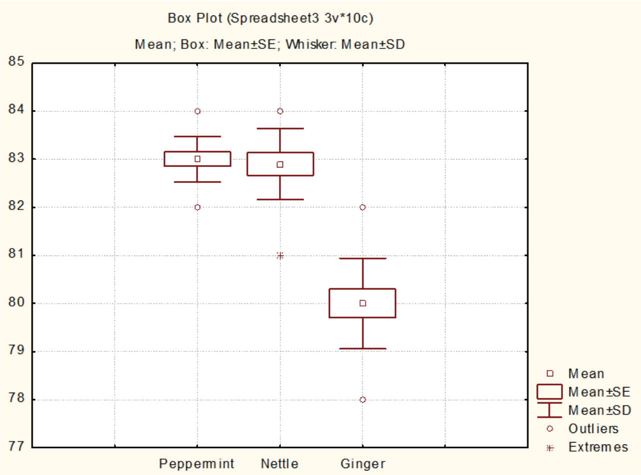

Fig. 8. Efficacy at day 7 after treatment (%)
Source: Authors' own elaboration

roots, stems, flowers, and fruits. They can be used as natural insecticides because they are inexpensive, safe, and environmentally friendly (Ratnasekera and Rajapakse, 2009; Thorayia et al., 2012; Al-Joary et al., 2021).

Conclusions

The compounds contained in plant extracts of ginger (*Zingiber officinale* L.), nettle (*Urtica dioica* L.) and peppermint (*Mentha piperita* L.) exhibit a toxic effect against the pollen beetle (*Brassicogethes/Meligethes aeneus* F.) and the red cabbage bug (*Eurydema ornata* L.).

In the case of the pollen beetle, the highest efficacy was reported for nettle and peppermint, which reached 99.7% on the 7th day.

In the case of the red cabbage bug, the plant extracts of peppermint and nettle show the most pronounced toxic effect, with an efficiency of 83%.

A gradual increase in efficacy was observed for all tested plant extracts.

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