The Journal of Agricultural Sciences - Sri Lanka
Vol. 20, No 2, May 2025. Pp 267-279
http://doi.org/10.4038/jas.v20i2.10669

Investigating the Allelopathic Potential of Turnip and Broccoli to Manage Field Dodder in Eggplant Cultivation by Ecological Means

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Received: 19th November 2024/Accepted: 24th April 2025

ABSTRACT

Purpose: *Considering that the field dodder is one of the most dangerous parasitic weeds that causes serious damage to cultivated crops, this study aimed to evaluate the efficiency of different control methods against field dodder and the damage caused by the field dodder to eggplant. As well, to determine the isothiocyanate content of turnip and broccoli plants using GC-MS analysis.*

Research Method: *This study was conducted during 2020 and 2021. The experiment examined control methods involving turnip and broccoli as pre-cultivation plants, later both incorporated into the soil separately during specific growth stages, and then both covered and uncovered with black polyethylene mulch, and black polyethylene mulch alone. Controls included plots free of field dodder (Control 1) and plots totally infested with field dodder (Control 2). Finally, all plots were cultivated with eggplant seedlings on rows.*

Findings: *The efficacy of control methods against field dodder in eggplant plots reached 95.81% in TM (turnip+BP mulch) , 92.30% in BM (broccoli+BP mulch), 91.25% in M (black polyethylene mulch alone), 68.26% in T (turnip alone), and 62.58% in B (broccoli alone) treatments. The highest eggplant yield of 8.396 tons/da was achieved in TM treatment. The field dodder caused a yield loss in eggplant by 82.16%, a decrease in eggplant height by 31.12%, and by 58.99% in the number of eggplant fruits in the* Con 2 treatment, where the plots were fully infested with filed dodder.

Originality/value: *The efficiency of cruciferous plants against field dodder is attributed to their isothiocyanates content as the highest percentage of isothiocyanate compounds was found in turnip by 56.6% and the lowest in broccoli by 30.47%.*

Keywords: *Allelopathy, Broccoli, Cruciferous plants, Ecological weed management, GC-MS, Isothiocyanate, Turnip.*

INTRODUCTION

Eggplant (*Solanum melongena* L.), which belongs to the Solanaceae family, is considered one of the most important vegetables for human consumption globally. In considering the nutritive values of eggplant it is rich in vitamins and provides significant amounts of protein, fibre and carbohydrates. It is a source of essential minerals such as magnesium, potassium, manganese and copper, as well as an important source of biologically active compounds such as antioxidants (Docimo *et al*., 2016; Butu and Rodino, 2019).

Eggplant, like all agricultural crops, is vulnerable to various pests, mainly weeds. It was reported that the loss in eggplant yield reached 92.5% when weeds were left without control (Almhemed and Ustuner, 2022). It has also been reported that weeds, even when controlled, can cause yield losses of up to 14.6% (Guncan, 2013). Parasitic weeds

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are a major concern to eggplant farmers globally as they can cause yield losses that may reach 80% depending on the type of parasitic weed and the infestation severity (Zare and Donmez, 2013; Ustuner, 2018). Field dodder (*Cuscuta campestris* Yunck.) is classified as one of the most dangerous parasitic weeds because it has a wide range of host plants (Dawson *et al*., 1994; Holm *et al*., 1997; Nadler-Hassar and Rubin, 2003). It was reported that the yield losses caused by field dodder to some cultivated crops such as eggplant, tomato, potato, and pepper varies between 50% and 90% (Nadler-Hassar and Rubin, 2003; Lanini and Kogan, 2005; Lian *et al*., 2006). In Iraq, the yield loss in the Barcelona hybrid eggplant variety reached to 27% as affected by field dodder (Al-Gburi *et al*., 2019).

Field dodder is considered a parasitic weed which is difficult to control by traditional methods due to the close relationship with the host and hard shell of seeds. The property of seed dormancy also makes the seeds in the soil capable of germination for up to 30 years (Mishra, 2009). It was reported that black polyethylene used as a mulch achieved 87.4% weed control of the field dodder in eggplant (Almhemed and Ustuner, 2022). Previous studies have indicated the allelopathic potential of some plants to control weeds (Teasdale and Mohler, 2000; Bilalis *et al*., 2003; Younis *et al*., 2012; Aslam *et al*., 2017). For example, 10% aqueous extract of Stinkwort (*Dittrichia graveolens* L.) reduced the germination rate of field dodder seeds by 76.2% under laboratory conditions (Almhemed *et al*., 2021). Many previous studies have reported that cruciferous plants, especially those belonging to the Brassica genus, have an allelopathic effects on their biosphere. This is due to the presence of isothiocyanates, which are active compounds resulting from the hydrolysis of glucosinolates (Uremis *et al*., 2009; Jabran *et al*., 2015; Cipollini, 2016).

This experiment aimed to evaluate the efficacy of selected control methods against field dodder, the effect of control methods on the growth of field dodder and the effect of field dodder on some morphological and productive characteristics of eggplant. Study also aimed to determine the isothiocyanate content of turnip and broccoli plants using gas chromatography-mass spectrometry (GC-MS).

MATERIALS AND METHODS

Experiment Location, Soil Characteristics, and Climate

This experiment was conducted at the trial area of the East Mediterranean Transitional Zone Agricultural Research Institute in Kahramanmaras, Turkey (37.53564°N, 36.91800°E) during the year 2020 and 2021. The soil analysis was conducted by collecting soil samples from 8 randomly selected points in the experiment land at a depth of 30 cm. These soil samples were analyzed at the USKIM laboratory in Kahramanmaras Sutcu Imam University (Table 1). Table 1 in the Appendix also shows the climatic pattern of the area prevailed for two years.

Experiment Design and Treatments

The experiment was conducted using a randomized complete block design (RCBD) in three replications. Each block consisted of 7 treatments (Table 02). The treatments applied were turnip alone (T1) and broccoli alone (T2) as pre-cultivation plants, turnip as pre-cultivation plants incorporated into soil followed by covering with black polyethylene mulch (T3), and broccoli as pre-cultivation plants incorporated into soil followed by covering with black polyethylene mulch (T4), and black polyethylene mulch alone (T5) (with a thickness of 100 microns).Furthermore, the experiment contained two control plots, i) completely free of field dodder (T6) and ii) field dodder was allowed to grow fully without any control (T7). The experimental plots' dimension was 10 m^2 (2×5m), 1m distance was left between the plots, 2 m space between two blocks, and 3 m space as a side effect area around the experiment land (Table 2).

Procedure of treatment imposition

Turnip (*Brassica rapa* L. subsp. *rapa*) and broccoli (*Brassica oleracea* L. var. *italica*) plants were cultivated as pre-cultivation plants in the experimental plots allocated to each one according to the experiment design. Broccoli seedlings (Sakura F1 variety) were cultivated on 18 Dec 2019, and on 20 Dec 2020 (2 Seasons as repeat experiment). Turnip (Kahramanmaras Salgam variety) seeds were sown on 10 Feb 2020 and on 11 Feb 2021 (2 Seasons as repeat experiment). Agricultural practices such as fertilizer application, irrigation, and pest prevention were undertaken as per the Directorate of Agriculture recommendations in the area. The plants were left in the field until the flowering stage in Turnip and the head formation stage in Broccoli and then were incorporated into the soil. Before incorporating plants, samples were taken from an area of one m^2 for each plant species. The samples included the entire plant, were dried in the laboratory to determine the amount of biomass of each plant species that was incorporated into the soil to a depth of 20 cm using a tractor equipped with a disc plow. In addition, samples of Turnip and Broccoli were prepared for GC-MS analysis to determine their content of isothiocyanate compounds.

It should be noted that the experimental field was infested with field dodder. However, field dodder seeds were sown at a rate of 2 g/m^2 on plots in order to have an even density in all plots. The dormancy of field dodder seeds was broken by exposing them to concentrated sulfuric acid (98%) for 5 minutes then rinsing the seeds with running water for 10 minutes (Almhemed *et al*., 2020).

After incorporating the pre-cultivated plants into the soil and blowing the field land, the plots assigned to mulch was thatched with black polyethylene sheets to cover the buried plant parts.

Eggplant seedlings of Adana variety (*S. melongena* var. *esculentum*) were cultivated on 11 May 2020 and on 12 May 2021, on plots with dimensions of 70×40 cm in two seasons. The field was irrigated on weekly basis, fertilizers were applied, and pest preventive measures were performed according to the guidelines of the Agriculture Directorate.

All weed species were removed from the experimental plots manually, and the field dodder was left to grow except for the control plots that were free of field dodder.

Data recording

The Effect of Control Methods on the Field Dodder Density : At the end of the experiment, the number of infected plants/m^2 and the number of infected branches for each plant were calculated. The percentage of infected branches was calculated using the following formula (1):

Table 1. Soil properties of the experiment land.

Parameter	Analysis results value	Analysis method
Saturation (%)	52.8	TS 8333
pH	7.36	TS 8332
Total salt (%)	0.15	TS 8334
$CaCO_3$ (%)	15.22	TS 8335 ISO 10693
Organic substances (%)	3.49	TS 8336
K (ppm)	231.7	Olsen method
P (ppm)	54.19	Olsen method

Table 2: The treatments imposed to the field experiment.

Treatments	Dose
T1) Broccoli alone (pre-cultivation plant)	1.56 kg/m^2 dry weight
T2) Turnip alone (pre-cultivation plant)	1.11 kg/m^2 dry weight
T3) Broccoli +Mulch (BM)	1.56 kg/m^2 dry weight
T4) Turnip +Mulch (TM)	1.11 kg/m^2 dry weight
T5) Black polyethylene mulch alone	-
T6) Control 1 (free of field dodder)	-
T7) Control 2 (with field dodder)	-

Infected branches percentage (%)= $\left(\frac{x-y}{x}\right)\times 100$ (1)

Where, x: the total number of eggplant branches per plant, y: the number of infected branches per plant.

The Effect of Control Methods on the Fresh and Dry Biomass Weights of Field Dodder : At the end of the experiment, field dodder plants were carefully collected from 01 m^2 area of each plot. The samples were placed in nylon bags and transported to the laboratory, and the fresh biomass weight of each sample was measured using an electronic sensitive scale (0.01g accuracy). After that, the samples were left to dry at room temperature (25±2 °C), then the dry biomass weight of each was measured.

Efficiency of Control Methods Against the Field Dodder: The control efficiency was calculated based on the effectiveness of each method in reducing the dry biomass weight of field dodde using the formula (2) proposed by Abbott (1925):

CE%= [(WNC -WNT) / WNC] × 100 (2)

Where, CE: is the control efficiency; WNC: is the dry biomass weight of the field dodder in the control 2; WNT: is the dry biomass weight of the field dodder in the treatment x.

The Effect of Control Methods on the Eggplan Height and Branches: At the end of the eggplan harvest season, 10 plants were randomly selected from each experimental plot, and the average plant height was calculated using a 2-meter ruler. To calculate the rate of decrease in plant height due to field dodder infection, the following formula (3) was used:

The rate of decrease in eggplant height = [1 - (Lx L0)] × 100 (3)

Where, Lx: is the eggplant height in the treatmen x, L0: is the eggplant height in the control 2. From the same random sample selected for ten plants, the number of branches per plant was calculated.

The Effect of Control Methods on the Number of Eggplant Flowers and Fruits: At the beginning of the eggplant flowering season, 10 plants were randomly selected, and the number of flowers was recorded before each harvest from each plot, thus obtaining the cumulative total number of flowers per plant. At the same time, the number of fruits for each plant was recorded with each harvesting process, and thus the cumulative number of fruits for each plant was obtained. The rate of decrease in the number of eggplant fruits as affected by field dodder infection, was calculated using the following formula (4):

Pl note from each plot means that it covers each treatment and each replicate. Mean value means the average of all (4) replicates.

The rate of decrease in the number of eggplant fruits = [1 - (Nx/N0)] × 100 (4)

Where, Nx: is the number of eggplant fruits in the treatment x, N0: the number of eggplant fruits in the control 2.

The Effect of Control Methods on Eggplant Yield and Yield Loss Caused by Field Dodder: The eggplant yield was calculated by aggregating the yields from all harvesting activities within a 1m^2 area of each plot to extrapolate the yield to tons per dunum (1000 m^2). To evaluate the impact of field dodder on eggplant yield, the yield loss rate was determined by comparing the yield of each treatment with that of the control 2 using the formula (5) below:

Eggplant yield loss rate = [1 - (Yx/Y0)] × 100 (5)

Where, Yx: Yield in x treatment, Y0: Yield in the control 2.

Identification of ITCs in Turnip and Broccoli: Turnip and Broccoli samples were prepared for GC-MS analysis in the laboratory of the Plant Protection Department at Kahramanmaras Sutcu Imam University following the method outlined by Vaughn and Berhow (2005). Initially, ten grams of plant powder were accurately weighed. The powder samples underwent a 24-hour defatting process using hexane in a Soxhlet extractor. Subsequently, the plant powders were dried completely in a fume hood. The defatted powders were mixed with 30 ml of 0.05M potassium phosphate buffer in separate flasks. To each mixture, 50 ml of dichloromethane was added, and the flasks were agitated at 25ºC and

200 rpm for 8 hours. Afterward, 10 g of NaCl and 10 g of Na_2SO_4 were introduced and thoroughly mixed. The mixtures were filtered with additional dichloromethane during the filtration process. The resulting dichloromethane solutions were transferred to labelled ampoules according to the respective plants for GC-MS analysis.

Statistical Analysis of Data

The experiment was commenced in 2020 and repeated in 2021. To assess the consistency of the data within each year, Levene test was employed followed by the t-test. The t-test indicated that there was no significant difference in means between two years. Consequently, the mean values both years were considered in result interpretation. For data analysis, ANOVA procedure with MSTAT-C software (Version 2.10) was employed. To compare means the Least Significant Difference (LSD) test was applied at a significance level of 0.05.

RESULTS AND DISCUSSIONS

The Effect of Control Methods on the Field Dodder Density

All treatments led to a reduction in the number of branches infected with field dodder compared to Cnt.2. No significant difference was reported between the TM (1.83) and BM (2.17) treatments, but they were significantly outperformed other treatments including Control 2. It was reported that the percentage of branches infested with field dodder reached the highest of 93.82% in Cnt.2, and against this percentage was significantly lower to 57.54%, 37.03%, 8.51%, 6.56%, and 5.50% in the treatments of B, T, M, BM, and TM, respectively. Likewise, the number of infested plants/m^2 3.7 was the highest in the Cnt.2, and it was significantly lower in the treatments of B, T, M, BM, and TM, as 2.3, 1.5, 0.3, 0.27, and 0.2, respectively (Table 3).

The Effect of Control Methods on the Fresh and Dry Biomass Weights of Field Dodder

It was reported that all treatments led to a reduction in fresh biomass of field dodder compared to Cnt.2. The percentage reduction in the fresh biomass of field dodder was 95.85%, 92.33%, 91.49%, 68.48%, and 62.35% in treatments TM, BM, M, T, and B, respectively compared to that of Cnt 02, accordingly and the TM treatment significantly outperformed the other treatments, while there was no significant difference between BM and M treatments. A same trend was reflected in dry biomass of field dodder, which recorded 22.7, 41.8, 47.5, 172.2, and 202.8 g/m^2 for the treatments TM, BM, M, T, and B, respectively, while it reached to 542.3 g/m^2 in the Cnt.2 (Table 4).

Efficiency of Control Methods Against Field Dodder

The controlling efficacy of field dodder was significantly different between treatment. The highest controlling efficacy was recorded in the

Table 3: The number and percentage of infected branches and the number of infected plants as affected by different treatments.

Treatments	The number of infected branches/plant	Percentage of infected branches per plant (%)	The number of infected plants/m^2
TM	1.83^b	5.50^b	0.2^b
BM	2.17^b	6.56^{Bc}	0.27^{bc}
M	2.77^c	8.51^c	0.3^c
T	10.57^d	37.03^d	1.5^d
B	13.20^e	57.54^e	2.3^e
Cnt.1	0.00^a	0.00^a	0.0^a
Cnt.2	13.10^e	93.82^f	3.7^f
LSD 0.05	0.5396	2.905	0.1258

Values followed by the same letter(s) in the same column are not significantly different from each other at P<0.05

TM treatment, reaching 95.81%, followed by the BM treatment, at 92.30%, while the lowest was in the B alone treatment, at 62.58% (Fig. 1).

Previous studies have demonstrated the effectiveness of mulch as control method against field dodder. In chickpea fields, mulching achieved a control efficiency of 93% (Shamse *et al*., 2013). Similarly, when black plastic mulch was employed in eggplant fields to control narrow and broad-leaf weeds as well as field dodder, it yielded controlling efficacy ranging from 85.33% to 87.42% (Almhemed and Ustuner, 2022). Furthernore, the application of black plastic mulch led to 89% to 98% reduction in parasitic weed infestation in tomato crops (Johnson *et al*., 2007). Additionally, studies have shown that using black plastic mulch against weeds can substantially decrease their dry biomass by 95% to 98% (Rajablariani *et al*., 2012). Similar to these findings black plastic mulch alone achieved a controlling efficacy of 91.25% against field dodder. When pre-cultivated plants were covered with black plastic mulch, the control efficiency was ranged from 92.30% to 95.81%, aligning with previous findings.

This study illustrates that the incorporation of turnip and broccoli plants into soil infested with field dodder seeds leads to a reduction in the soil's field dodder seed bank. Consequently, there is a decrease in the number of germinated field dodder seeds, as evident by a reduced dry biomass of field dodder per square meter. When turnip and broccoli plants were incorporated into the soil before cultivating eggplant, the resulting controlling efficacy was ranged from 62.58% in the broccoli to 68.26% in the turnip treatment. These findings align with previous studies, (Kalinova, 2010), which reported a 72% reduction in parasite seed bank when cruciferous plants were incorporated into the soil.

The effect of cruciferous plants on the field dodder is attributed to the hydrolysis products of glucosinolates (GLSs), particularly isothiocyanates (ITCs), which form in the presence of Fe^{2+} ions and an acidic pH. The concentration of GLSs in cruciferous plants, particularly those in the Brassica family, has been well documented (Motmainna *et al*., 2021; Weston *et al*., 2013; Petersen *et al*., 2001). This study reported the ready formation of ITCs in a slightly acidic soil with a pH of 7.36, consistent with other research indicating that GLS hydrolysis under neutral conditions in the presence of Fe^{2+} ions and at an acidic pH typically results in ITC formation (Bones and Rossiter, 1996). ITCs are known for their high bioactivity against weeds, underscoring their potential as a natural herbicide (Martins *et al*., 2004).

Table 04: Field dodder fresh and dry biomass and percentage reduction of fresh biomass as affected by the treatments.

Treatments	Field dodder fresh biomass g/m^2	Percent of fresh biomass reduction (%)	Field dodder dry biomass g/m^2
TM	73.5^b	95.85^b	22.7^b
BM	136.0^c	92.33^c	41.8^c
M	150.8^c	91.49^c	47.5^c
T	559.0^d	68.48^d	172.2^d
B	667.5^e	62.35^e	202.8^e
Cnt.1	0.0^a	100.00^a	0.0^a
Cnt.2	1774.0^f	0.00^f	542.3^f
LSD 0.05	36.18	1.002	8.252

Values followed by the same letter(s) in the same column are not significantly different from each other at P<0.05

The Effect of Control Methods on the Eggplant Height and Branches

Eggplant height ranged between a minimum of 78.00 cm in Cnt.2 and a maximum of 113.2 cm in Cnt.1. No statistically significant differences in plant height were observed between treatments of TM and BM as well as between treatments of BM and M, reported as 106.1, 105.0, and 104.1 cm , respectively. The corresponding percentage decrease in plant height caused by Cnt 2 was 31.12% whereas it was only 7.26%, and 6.36% for in the treatments BM, and TM, respectively.

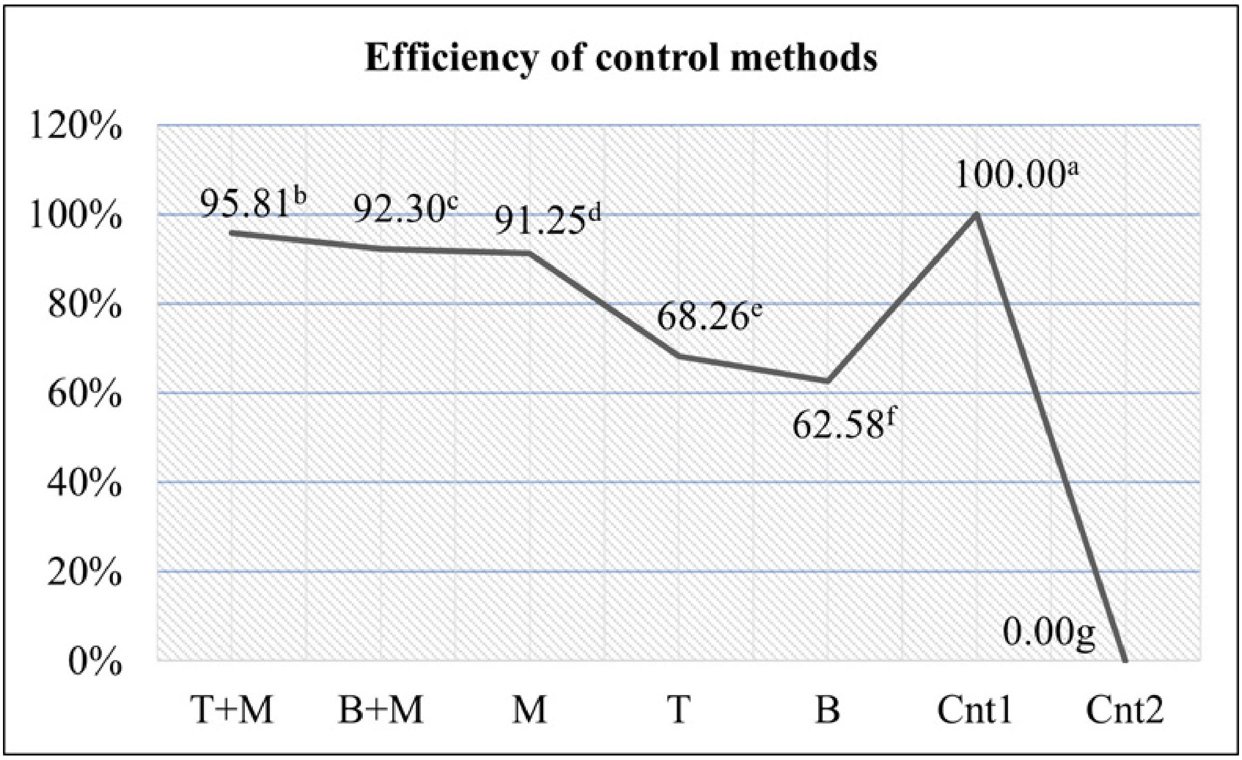

Figure 1: Efficiency of control methods against the field dodder. [Values followed by the same letter(s) are not significantly different from each other at P<0.05 (LSD 0.05= 0.7442)].

Table 5: The eggplant height, the percentage decrease in the eggplant height, and the number of eggplant branches.

Treatments	The eggplant height (cm)	The percentage decrease in the egg-plant height (%)	The number of branches/egg plant
TM	106.1[b]	6.36[b]	33.43[b]
BM	105.0[bc]	7.26[bd]	33.00[b]
M	104.1[c]	8.06[d]	32.73[b]
T	93.63[d]	17.33[c]	28.50[c]
B	90.33[e]	20.22[e]	22.97[d]
Cnt.1	113.2[a]	0.00[a]	37.77[a]
Cnt.2	78.00[f]	31.12[f]	13.93[e]
LSD 0.05	1.191	1.067	0.7672

Values followed by the same letter(s) in the same column are not significantly different from each other at P<0.05

No significant differences between treatments TM, BM, and M were observed in the number of branches per egg plant, which was ranged between 32.73 and 33.43. However, these were significantly higher than that of Cnt 2, T and B i.e. 13.93, 28.50 and 22.97, respectively Table 5).

The Effect of Control Methods on the Number of Eggplant Flowers and Fruits

The highest number of flowers was recorded in Cnt.1 at 34.00, and the lowest was 13.97 flowers/plant in Cnt.2 and the difference was significant. There were significant differences in the flower number between the treatments of TM, BM, M, T, and B which recorded 29.27, 27.23, 25.70, 21.13, and 17.63 flowers/plant respectively.

Similar pattern of variation in eggplant fruits

Table 6: The number of eggplant flowers, eggplant fruits, and the percentage decrease in the number of fruits.

Treatments	The number of eggplant flowers/ Plant	The number of eggplant fruits/ Plant	The percentage decrease in the number of fruits per plant (%)
TM	29.27[b]	28.07[b]	12.35[b]
BM	27.23[c]	25.63[c]	19.89[c]
M	25.70[d]	24.33[d]	24.01[d]
T	21.13[e]	20.00[e]	37.56[e]
B	17.63[f]	16.80[f]	47.55[f]
Cnt.1	34.00[a]	32.03[a]	0.00[a]
Cnt.2	13.97[g]	13.13[g]	58.99[g]
LSD 0.05	0.9630	1.043	3.207

Values followed by the same letter(s) in the same column are not significantly different from each other at P<0.05

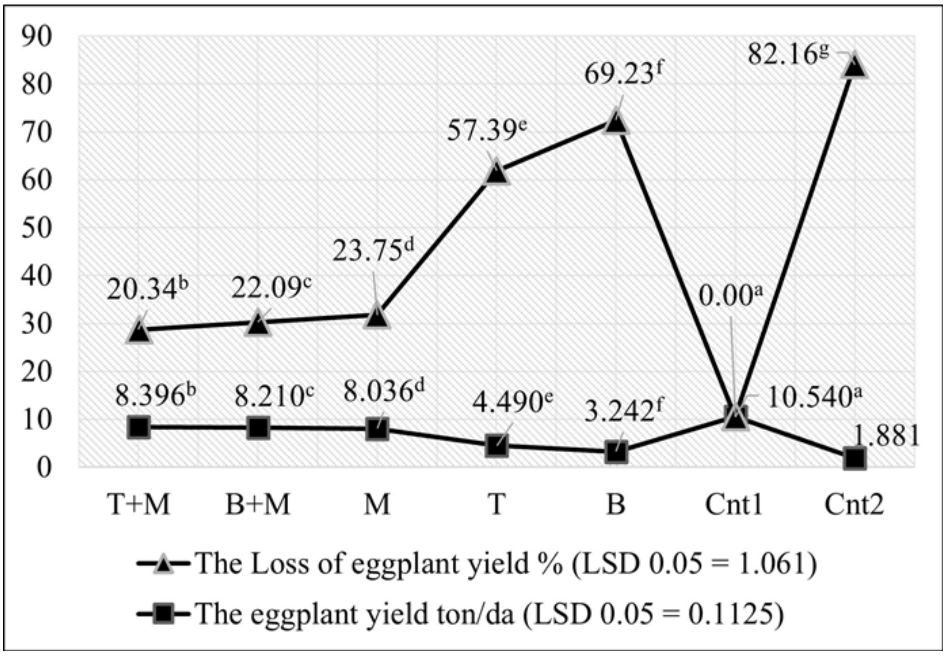

Figure 2: Eggplant yield and yield loss caused by field dodder. (Values followed by the same letter(s) in the same series are not significantly different from each other P<0.05).

number and the percentage as on the flower number as above, was reported. The highest number of eggplant fruits was recorded in Cnt.1 at 32.03, and the lowest was 13.13 fruits per plant in Cnt.2 and the difference was significant. There were significant differences between the treatments in fruits number, which recorded 28.07, 25.63, 24.33, 20.00, and 16.80 fruits per plant in the TM, BM, M, T, and B treatments, respectively. Field dodder caused almost 59% decrease in the number of eggplant fruits/plant in Cnt.2, whilst it was only 19.89%, and 12.35% in the treatments of BM, and TM, respectively (Table 6).

The Effect of Control Methods on Eggplant Yield and Yield Loss Caused by Field Dodder

The highest eggplant yield of 10.54 tons/da was recorded in Cnt.1 which was significantly greater than that of Cnt 2 which was the lowest (1.881 tons/da). Further, there were significant differences in yield between each of the treatments of TM, BM, M, T, and B , which recorded 8.4, 8.21, 8.04, 4.49, and 3.24 tons/da in the , respectively.

Field dodder had thus caused 82.16% loss in eggplant yield inCnt.2 where the plots were fully infested with Field dodder. Whereas this percentage decrease under the TM and BM and M was 20.39%, 22.1% and 23.81%, respectively (Fig. 2).

Identification of ITCs in Turnip and Broccoli

Six different isothiocyanate (ITC) compounds were detected in turnip, including Allyl ITC, 3-Butenyl ITC, Cyclopentyl ITC, Heptyl ITC, Phenethyl ITC, and Octyl ITC. The cumulative ITC compounds constituted 56.6% of the total, with Allyl ITC being the most abundant, accounting for 17.24% of the total.

These findings are in agreement with previous study which reported that turnip contained three ITC compounds, namely 2-Phenylethyl, 4-pentenyl, and 3-butenyl (Paul *et al*., 2019). Similarly, another study identified six ITC compounds in turnip, with variations across different plant parts: N-butyl ITC and 3-butenyl ITC in the roots, Benzyl ITC, Allyl ITC, and 4-pentenyl ITC in the leaves and flowers, and 2-phenylethyl ITC in the entire plant (Petersen *et al*., 2001). Additionally, present study findings corroborate those of another study, which identified eight ITC compounds in turnip, including Allyl ITC, Sulforaphane, Benzyl ITC, Phenethyl ITC, Iberin, Methylthiobutyl ITC, Napin, and Goitrin (Vieites-Outes *et al*., 2016).

In the case of broccoli, four distinct ITC compounds were found including Allyl ITC, Raphasatin, Iberin, and Sulforaphane. The collective ITC compounds comprised 30.47% of the total, with Sulforaphane being the primary ITC compound, making up 16.27% of the total.

Table 7: Kinds and percentage of ITC compounds in turnip and broccoli based on the GC-MS analysis.

Cruciferous plants	Isothiocyanate compounds	Percentage (%)
Turnip	Allyl ITC	17.24
	3-Butenyl ITC	10.09
	Cyclopentyl ITC	6.35
	Heptyl ITC	12.44
	Phenethyl ITC	5.96
	Octyl ITC	4.52
	Total	**56.6**
Broccoli	Allyl ITC	1.24
	Raphasatin	7.14
	Iberin	5.82
	sulforaphane	16.27
	Total	**30.47**

These findings have some consistency with the previous study that indicated the presence of three ITC compounds (Allyl ITC, Phenethyl ITC, and Iberian) in broccoli (Wang *et al*., 2010). Furthermore, various studies have documented the presence of multiple ITC compounds in broccoli, including Sulforaphane, Iberian, Erucin, Allyl ITC, and Phenethyl ITC (Chiang *et al*., 1998; Liang *et al*., 2006; Lv *et al*., 2021). One study found that the flowers of broccoli have the highest Sulforaphane content (Yadav *et al*., 2022). In summary, the findings of this study are partly in accordance with the conclusions drawn in previous studies (Table 7).

CONCLUSIONS

The results indicate that thatching the ground with black plastic mulch is an effective control method for field dodder. Furthermore, promising control of field dodder can be achieved with pre-cultivation of either Turnips or Broccoli and incorporating of either plants into soil before field planting of eggplants followed by thatching with black plastic mulch. Cruciferous plants like turnip and broccoli can thus be utilized as an eco-friendly strategy to manage field dodder and hence, as a substitute for herbicides.

Acknowledgements

The authors are grateful to Prof. Dr. Hamdullah KILIC from Ataturk University, Faculty of Science, Department of Chemistry, who provided great support about conducting the GC-MS analysis.

Conflict of Interest

The authors declared no conflicts of interest with this research work.

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Appendix table 1: Some climatic pattern of Kahramanmaras province for two years 2020 and 2021.

Months	Minimum temperature (°C)		Maximum temperature (°C)		Average temperature (°C)		Average relative humidity (%)		Total precipitation (mm)	
	2020	2021	2020	2021	2020	2021	2020	2021	2020	2021
January	-4.2	-4.4	14.1	13.9	5.0	4.8	82.3	84.1	105.8	116.5
February	-9.2	-9.7	18.7	18.3	4.8	4.3	78.1	81.3	75.2	82.4
March	0.3	0.2	25.9	25.4	13.1	12.8	74.6	75.1	4.6	8.2
April	0.4	0.3	30.9	30.6	15.7	15.5	66.1	66.4	33.0	34.3
May	7.5	7.3	41.2	40.8	24.4	24.1	54.4	55.7	23.0	24.3
June	11.4	11.8	41.0	40.7	26.2	26.3	50.2	51.1	0.0	1.2
July	18.5	19.1	44.6	44.2	31.6	31.7	46.4	46.2	0.0	0.0
August	15.9	16.1	45.0	45.5	30.5	30.8	40.9	41.1	0.0	0.0
September	17.1	17.3	45.5	46.1	31.3	31.7	42.9	43.2	0.0	0.0
October	8.1	8.5	35.9	36.2	22.0	22.4	39.1	39.3	0.4	0.7
November	-	-	-	-	-	-	-	-	-	-
December	-	-	-	-	-	-	-	-	-	-
Average	6.6	6.7	34.3	34.2	20.5	20.4	57.5	58.4	24.2	26.8