CATRINA (2021), 24(1): 81-88

The Effect of Biofumigation with Various Brassicaceae Plants on the Number and Diversity of Soil-Borne Fungi in Arish City, Egypt

Monga Ibrahim Mossa
Department of Botany and Microbiology, Faculty of Science, Arish University, North Sinai, Egypt

ABSTRACT

Biofumigation is a pest control strategy that involves the use of glucosinolate-producing plants, usually from the Brassica family. When these plants' tissues are damaged, an enzyme breaks down the glucosinolates, releasing a variety of chemicals that are known to be plant pathogen suppressors. In this study, applying this technique using Brassicaceae species such as cauliflower (*Brassica oleracea*, var. *botrytis* L.), radish (*Raphanus sativus*), watercress (*Eruca sativa*), canola (*Brassica* napus), cabbage (*Brassica oleracea* var. *capitata* L.), and turnip (*Brassica rapa*) was successful in lowering the count of soil-borne fungi compared to control. In meantime, it increased the water holding capacity of soil. As a result, the percentage of organic matter (OM%) and organic carbon (OC%) increased. The highest percentage of OM (2.03 and 2.45 %) and OC (1.19% and 1.42%) were recorded when applying canola and cauliflower plants, respectively. The average colony forming unit (CFU) for soil-borne fungus following biofumigation (211.6 X 10^3 /ml of soil extract) was lowered compared to those obtained before and during plant growth treatment (810.9 x 10^3 and 1533.2 X 10^3/ml, respectively). For the most common plant pathogen like *Fusarium lateritium*, biofumigation recorded a significant reduction in colony number/ml of soil extract compared to those recoded during plant growth and the control soil without treatment (30.0, 48.0 X 10^3 and 128.4 and CFU ml^{-1}, respectively). Among genera of Brassica family used, canola, radish and cabbage were significantly the highest in reduction of fungal count. In general, biofumigation changed the measured soil properties as well as the composition of the soil-borne fungus community, causing the extinction of some genera and the emergence of others.
Keywords: Biofumigation; Brassicaceae; Canola; Cabbage; Soil-borne fungi

INTRODUCTION

Managing the food needs of a fast growing global population is proving to be a major challenge for humanity. In developing countries, such as Egypt, population growth is predicted to be more rapid. Urbanization, climate change, and the utilisation of land for non-food crop cultivation all worsen these worries about rising food demands. Most countries' plans to deal with rising food demand over the previous few decades have concentrated on enhancing agricultural production, land usage, and population control. In Egypt, enhance crop yield is considered one of the major strategy to meet the demand for food required. The parasitic fungi are considered among factors that lead to reduce crop productivity and cause crop losses in storage. Pest management strategies have included the applying of different tools including the biofumigation process (BFP) by natural growing plants mainly Brassicaceae plants (Cruciferous plants).

Biofumigation term, first coined by Kirkegaard, is the process of growing, macerating, or incorporating certain Brassica or related species into the soil, which results in the release of isothiocyanate compounds (ITCs) from the hydrolysis of glucosinolate (GSL) compounds in the plant tissues. Biofumigation affects soil structure, microbial communities, parasite control, and soil quality (Degens, 1998; Kumar, 2005; Gimsing et al., 2006; Hoshino and Mataverageoto, 2007; Roubtsova *et al*., 2007; Gimsing and Kirkegaard, 2008; Wang et al., 2010; Omirou *et al*., 2011; Szczyglowska *et al*., (2020). Natural isothiocyanates are poisonous to pests, nematodes, and fungus that live in the soil (Ntalli and Caboni 2017). Soil BFP has been found to reduce disease incidence and decrease soil-borne pathogens (Kumar, 2005; Omirou *et al*., 2011). The count of some soil-borne fungi and pathogens was reduced after fumigation such as; *Penicillium* spp., *Alternaria* spp., *Fusarium oxysporium*, *F. solani*, *Mortierella* spp., *Cladosporium* spp., *Pythium* spp., *Verticillium* spp. *Rhizoctonia* sp., *Phytophthora* spp. (Cal *et al*., 2005; Smolinska and Kowalczyk, 2014; Hu *et al*., 2015) root knot nematodes (Kruger *et al.,* 2013; Charles *et al*., 2015) and fungal potatoes pathogens (Taylor, 2013). This process has an effect on fungi greater than bacteria (Yim *et al*., 2015). A number of Brassicaceae spp. are used in the BFP process including Brassica *oleracea*, *B. juncea*, *B. rapa*, *Eruca sativa*, *Raphanus sativus*, and *B. napus* (Fan et al., 2008; Kruger *et al*., 2013; Handiseni *et al*., 2016; Yim *et al*., 2016).

There are other benefits for the BFP by enhancing soil structure, soil preservation, and enhancing plant growth. It has an effect on the life cycle of pests and parasites through its biocidal activity and changes the soil fauna and communities (Ntalli and Caboni, 2017). Furthermore, macro- and micro-nutrients are affected by the BFP (Motsara and Roy, 2008). The degree of hydrolysis of glucosinolate is of major importance. Therefore, covering the soil is a critical step in the process of BF to increase the temperature of soil in order to increase the quantity of volatile isothiocyanate compounds released to soil. Soil organic matters are an

*author e-mail: monga.ibrahim@aru.edu.eg

indicator for soil quality as they have an impact on the nutrient supply, soil structure, and soil temperature. Biofumigation increases the content of soil with N, NO_3, P, and K (Wang *et al*., 2010). Soil pH is very important as it influences on the availability of nutrients for crops and the microbial populations in the soil (Motsara and Roy 2008). Therefore, this study was carried out to evaluate the effect of the biofumigation process with selected Brassicaceae species on the count and composition of soil-borne fungi under field conditions in Al-Arish City, North Sinai.

MATERIALS AND METHODS

Brassicaceae plants used

The different genera of the family Brassicaceae were selected to study their effect on soil properties and soil-borne fungi. List of the plant used is illustrated in Table (1). These include turnip, Salad rocket, canola, cabbage, cauliflower and radish.

Table (1): Common and scientific name of Brassicaceae plant genera used in Biofumigation process.

Common name	Scientific name	Plant type
Turnip	*Brassica rapa subsp. rapa*	Root vegetables
Salad rocket	*Eruca vesicaria subsp. sativa*	Leafy green vegetables
Canola	*Brassica napus*	Crop plant with 45% seed-oil content
Cabbage	*Brassica oleracea var. capitata L*	Green leafy vegetables
Cauliflower	*Brassica oleracea, var. botrytis L.*	Leafy green vegetables
Radish	*Raphanus sativus*	Root vegetable

Study area and treatment

Biofumigation was performed under field condition in one experiment according to Lord et al. (2011) and Kruger *et al*. (2013). The total cultivated area was divided into seven areas, one not cultivated with Brassicaceae species (control), and the rest were cultivated with; cauliflower, radish, salad rocket, canola, cabbage, and turnip. The Brassicaceae species were cultivated in the farm of the Faculty of Agriculture and Environmental Science, Arish University, for about three months, plowed in soil by slashing with a slasher after flowering, the macerated plant parts were irrigated, then the soil was covered by a polyethylene cover for one month to increase the temperature of soil to complete the process of biofumigation.

Samples collection

For each treatment, 200 g of soil samples were taken from a depth of 10 cm. Each sample has five subsamples, one for each location. Before planting the Brassicaceae plants, a control sample was taken from the field. The second sample was taken during the growing of the selected crops. The third sample was taken after the biofumigation process ended for about one month and before growing the new crops.

Effect of BF on soil pproperties

Water holding capacity (WHC)

The soil samples were passed through 2 mm sieve to determine the soil texture and soil pH. The values of WHC for soil before and after BF were determined according to **Motsara and Roy (2008)** based on the following equation:

$$WHC(\%) = \frac{ms - md}{md - mb} \chi 100$$

Where; ms: mass of beaker containing water saturated soil, $m_{d:}$ mass of beaker containing oven-dried soil, m_b: mass of beaker. Two replica were used for each sample.

Organic carbon (OC%) and organic matters (OM%)

The and OC% and OM% were determined by direct measuring of the loss in weight on ignition, according to Motsara and Roy (2008) based on the following equations:

$$OM\ \% = \frac{(W1 - W2)}{W1} \text{ X } 100$$

Where; W_1: is the weight of soil at 105ºC, W_2; is the weight of soil at 400 Cº±25ºC for 4 hr. However, taking into account that each sample was replicated twice, the OC percentage was determined as follows:

$$OC\ \% = OM\% \text{ X } 1.72.$$

Fungal count and isolation technique

According to Jaime-Garcia and Cotty (2006), the count of fungal colonies was calculated as the number of colony forming unit (CFU) per gram of soil for each treatment. Fungi were isolated from soil sample following the method of Suhail *et al*., (2006) and Sarhan *et al*., (2020) in which serial soil dilution pour plate technique was carried out using potato dextrose agar medium (PDA). The medium consists of (g/L): 200 g potatoes, 20 g dextrose and 20 g agar. Inoculated Petri-dishes were incubated for 5 to 7 days at 28±1 ºC. Isolated fungi were transferred to new Petri dishes with PDA and grouped to the level of genus and identified according to their morphological and microscopic characters (Dhingra and Sinclair, 199). Soil fungal populations were estimated before, during plant growth and after the BF process using different genera of the family Brassicaceae.

Statistical analysis

Analysis of variance for data was performed using Excel 365 to determine the effect of treatments as average ± standard error (SE). One way ANOVA was performed to evaluate the effect of different Brassica on the different measurement parameters. Duncan's Multiple Range Test at $p \leq 0.05$ level was applied.

RESULTS

Soil properties and the effect of biofumigation

The soil texture of the studying area was sandy soil where it composed of 45.15 % sand, 26.50% fine sand, 22.36 % silt and 5.87 % clay. The pH of the soil was slightly to moderately alkaline, ranging from pH 7.9 to 8.1. When comparing soil before and after cultivation with different Brassicaceae plants, there was a consid-

erable difference in WHC %, OM %, and OC % (Figure 1). All of the evaluated parameters revealed significant increases in the soil analysis results. The highest WHC % was found in soil with the most cultivated plants, with the exception of turnip, which had a significantly lower value ($p \leq 0.05$). Meanwhile, cabbage plant recorded the highest for WHC compared to control and turnip with significant differences at $p \leq 0.01$ level. Meanwhile, among the rest of cultivated plants no significant differences were recorded (26.15, 26.8, 27.7, 26.31 for Salad rocket, Canola, Cabbage, Cauliflower and radish verses to 20.33 and 24.424.4 for control and turnip, respectively).

In addition, the percent of OC recorded the highest value with cauliflower followed by canola and cabbage

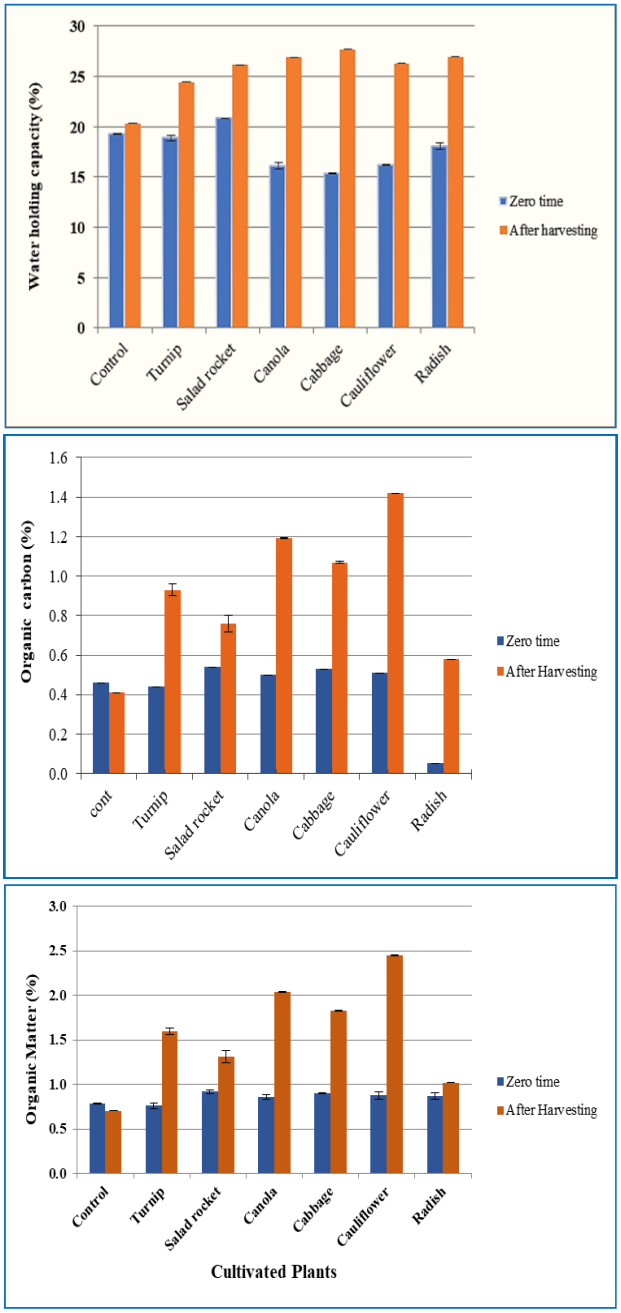

Figure (1): The effect of Biofumigation process with selected Brassicaceae species on mean value of WHC, % of OC% and OM% under field condition.

plants (1.42, 1.185 and 1.065%, respectively) after being cultivated compared to soil without cultivation or with other cultivated plants.

Likewise, OM% was also significantly ($p \leq 0.05$) the highest with cauliflower plant (2.45), after harvesting, compared to controlled soil (0.7 %). Meanwhile, canola and cabbage plants also recoded significant increase in OM% compared to control but were less than cauliflower plant (Figure 1).

Fungal isolate obtained

The most common fungal isolates inhabited the soil in the study area were *Aspergillus flavus*, *Aspergillus niger*, *Fusarium lateritium*, *Rhizopus* sp., and *Mucor* sp. The genus *Aspergillus* sp. was the frequent recorded isolate and three species were identified (Table 2). The identification of fungal isolates was done based on their micromorphological and macromorphological characteristics. The identification of genus *Fusarium* was confirmed by Assiut University, Assuit, Mycological Center, as *Fusarium lateritium* Nees, No.13626. The total average of fungal count was expressed as CFU $X10^3$ CFU/ml in which the highest significant ($p \leq 0.01$) count was recorded during cultivation state of each type of the Brassica plant used (Table 2). Cauliflower and radish and were the highest in fungal count during plant cultivation (320 and 316.7 $X10^3$ CFU ml^{-1}, respectively). However, all fungal count was significantly suppressed by biofumigation process compared to those before and during the cultivation of selected plants (Table 2).

Penicillium species were not recorded in soil before cultivation for any of the Brassica plants studied. Meanwhile, it was detected in significant numbers during plant cultivation. For *Penicillium* .sp.1, cabbage plant recorded the highest appearance of this genus (93. $X10^3$ CFU ml^{-1}) followed by the cauliflower plant (83.3 $X10^3$ CFU ml^{-1}). In comparison to the other plants studied, rocket salad, canola, and turnip had the lowest significance ($p \leq 0.01$) occurrence of this genus (5.0, 30.0 and 30.0 $X10^3$ CFU ml^{-1}, respectively). *Penicillium* sp.2 was not detected in control soil at any of the sites where selected plants were grown. When compared to the other Brassica plants, cauliflower had significantly ($p \leq 0.01$) the highest stimulated appearance of *P*.sp.2 (115. $X10^3$ CFU ml^{-1}).

Aspergillus was isolated as the second genus with a variable population count (Table 2). *A. niger* and *A. flavous* were detected in all of the control soils used for diverse Brassica growth, with the exception of *A. ochraceus*, which was not detected in any of the controlled locations (Table 2). During the growth of Brassica plants, the fungal count of all detected *A.* species rose, with *A. ochraceus* being the most numerous with turnip plants (93. $X10^3$ CFU ml^{-1}). Canola, on the other hand, had the highest *A. niger* count (66.8 $X10^3$ CFU ml^{-1}).

All soil utilized prior to Brassica cultivation had a reasonable fungal count for *F. lateritium* with non-significant ($p \leq 0.05$) differences recorded among them (Table 2). However, the count of this genus was

suppressed during plant growth, and the extent of this suppression varied depending on the plant variety cultivated. Meanwhile, following the biofumigation process applying radish, cauliflower, and canola plants recorded a complete (100%) reduction in *F. lateritium*.

The soil under investigation before treatment showed a higher CFU count for *Rhizopus* sp than the treated soil with Brassica cultivation during the growth stage, with the exception of canola and cabbage plants. Soil under these plants had a significantly higher count (10.0 and 6.7 $X10^3$ CFU ml^{-1}, compared to 20.0 and 10.0 $X10^3$ CFU ml^{-1} for canola and cabbage plants for treated and untreated soil, respectively). Meanwhile, Rocket salad, cabbage and radish plants showed complete suppression of this fungus after Biofumigation process (Table 2).

For *Mucor* sp., the soil under examination recorded a greater count at zero time compared to all plant growth stages (Table 2). The highest fungus count was found in the soil used for cabbage and cauliflower plants (33.34 and 33.3 $X10^3$ CFU ml^{-1}). However, the cabbage plant had a strong inhibitory effect on *Mucor* sp. count during growth and after fumigation (33.4 verses to 10 and zero $X10^3$ CFU ml^{-1}, for untreated to treated during plant growth and after Biofumigation, respectively).

In General, fungus counts varied across the investigated soil prior to Brassica cultivation. The fungus count, on the other hand, increased throughout the selected plant cultivation, particularly at the plant's growth stage. Meanwhile, the majority of soil after biofumigation displayed remarkable fungal suppression for fungal genera identified (Table 2).

DISCUSSIONS

The BFP method improved the physical and chemical soil properties. The higher percentage of WHC following BFP can be explained by changes in soil structure caused by hydrolysis of *Brassica* plant tissue, as well as the action of soil mycoflora. These new derivatives and components changed the constitution of soil, affecting its ability to retain water. This finding is consistent with Kumar (2005), Omirou *et al*. (2011), Reddy (2011), Szczyglowska *et al.* (2011), Wang *et al.* (2014), Ntalli and Caboni (2017), and Hanschen and Winkelmann (2018). (2020).

Based in our data, the biofumigation technique raised the percentage of OM and OC in soil, altering the soil structure and improving soil quality. These findings are consistent with those of Kumar (2005), Gimsing *et al*. (2006), Hoshino and Mataverageoto (2007), Wang *et al.* (2010), Wang *et al*. (2013), Omirou et al. (2011), Reddy (2011), Ntalli and Caboni (2017), Bui and Desaeger (2021), and Sarhan *et al*. (2020). Meanwhile, fungal-soil borne was suppressed pathogens after BFB process. Improving soil properties and reduction of fungal pathogen related to chemical compounds that exist with these plant types. The tissues of Brassicaceae spp. contain glucosinolates, which were naturally absorbed into the soil as manure by ploughing and covering the soil, reduced the microbial count and affected the community composition of soil-borne fungus. In comparison of fungal CFU/ml of soil before and after biofumigation, the Brassicaceae plants demonstrated their naturally biocidal action.

As demonstrated by our findings, there is a variation in the count and community of soil-borne fungi before, during, and after BF. The cultivation of the selected Brassicaceae plants reduced fungal CFU/ml of soil samples as well as their variety. Some fungal species appeared and disappeared during the growth of grown selected plants. Many scientists achieved similar results (Rudolf *et al*., 2001; Szczyglowska *et al*., 2011; Taylor 2013; Wang *et al*., 2014; Charles *et al*., 2015; Ntalli and Caboni, 2017). The count of *Fusarium lateritium* before and after biofumigation revealed that the BFP was efficient in reducing fungal count as a result of the change in soil structure caused by treatments with Brassicaceae species. These findings are consistent with those of Kumar (2005), Omirou *et al*. (2011), Wang *et al*. (2014), and Sarhan *et al*. (2015). (2020). The sensitivity of the fungal count differed according on the kind of Brassicaceae applied in BF. Canola and radish were more effective in suppressing *F. lateritium* and the other separate fungus species. This result is consistent with the findings of Fan *et al*. (2008). In addition, soil fungus susceptibility to Brassicaceae species was varied. It can be explained by the degree of inhibition based on the degree of hydrolysis of plant components, crop biomass, and fluctuation of glucoseinolate quantity (Fan *et al.,* 2008; Lord *et al*., 2011; Szczyglowska *et al*., 2011; Kruger *et al.,* 2013; Taylor, 2013; Charles *et al.,* 2015; Srivastava and Ghatak, 2017).

As previously stated, there were variations in the composition of soil-borne fungi before, during, and after Biofumigation. There were five fungus species before BFP (*A. flavus*, *A. niger*, *Fusarium lateritium*, *Rhizopus* sp. and *Mucor* sp.). Two *Penicillium* spp. and *Aspergillus ochraceus* were found during treatment growth. *Penicillium* spp. vanished after BFP.

BFP reduced the fungal CFU ml^{-1} of soil sample. These findings can be explained by the decomposition of plant tissue, which enriches the soil with extra organic matter, enhancing the growth of some fungus while suppressing others. The rationale for the influence of BFP on the composition of soil-borne pathogens and fungi is consistent with Hanschen and Sarhan *et al.* (2020), Hanschen and Winkelmann (2020), and Bui and Desaeger (2021). During the growth of Brassicaceae species, the fungal count, in general, increased and rarely can be inhibited. This can be explained by the ability of plant roots can excrete organic substances that enhance or inhibit soil-borne fungus. These hypotheses coincide with Kumar (2005), Omirou *et al* (2011), and others (Lored *et al*., 2011). According to Kumar (2005), "the roots of Brassicaceae may emit volatile isothiocynates (ITCs) during growth as well as decomposition."

There were decreases in CFU/ml of soil for all species after biofumigation with different Brassicaceae species, but the degree of reduction differed by species. Canola and radish had the lowest CFU/ml of soil extract values, followed by cauliflower, which had the

Table (2): Different fungus genera were frequently detected at various stages of plant cultivation, including before, during, and after the biofumigation process using selected Brassica plants.

	Plant common Name	Trea ǂ	Detected Fungal Isolate (CFU X 10^{-3}/ml)								Total count
			***Penicillium* sp.1**	***Penicillium* sp.2**	***A. ochraceus***	***A. niger***	***A. flavus***	***F. lateritium***	***Rhizopus* sp.**	***Mucor* sp.**	
Selected Brassica species	**Turnip**	1	0.00 ±0.00 ^{a}	0.00 ±0.00 ^{a}	0.00 ±0.00 ^{a}	6.7 ±0.09 ^{b}	66.7 ±0.88 ^{d}	23.3 ±0.23 ^{c}	23.3 ±0.23 ^{c}	6.7 ±0.09 ^{b}	126.7±22.5
		2	30.0 ±0.08 ^{b}	53.3 ±1.43 ^{e}	93.3 ±1.34 ^{f}	30.0 ±0.00 ^{cd}	25.0 ±0.45 ^{c}	16.3 ±0.19 ^{bc}	26.4 ±0.12 ^{c}	0.00 ±0.00 ^{a}	247.3 ±43.3
		3	0.0 ±0.00 ^{a}	0.0 ±0.00 ^{a}	0.0 ±0.00 ^{a}	0.0 ±0.00 ^{a}	20.0 ±0.00 ^{c}	10.0 ±0.00 ^{b}	10.0 ±0.00 ^{b}	0.00 ±0.00 ^{a}	40.0 ±0.0
	Rocket salad	1	0.00 ±0.00 ^{a}	0.00 ±0.00 ^{a}	0.00 ±0.00 ^{a}	6.7 ±0.08 ^{b}	56.7 ±0.33 ^{e}	20.0 ±0.57 ^{c}	40.0 ±0.94 ^{d}	20.0 ±0.00 ^{c}	143.4 ±17.1
		2	5.0 ±0.08 ^{b}	43.3 ±0.00 ^{e}	90.0 ±0.45 ^{f}	23.3 ±0.09 ^{c}	30.0 ±0.00 ^{d}	10.0 ±0.02 ^{b}	20.0 ±0.00 ^{c}	16.7 ±0.08 ^{c}	238.3 ±7.4
		3	0.00 ±0.00 ^{a}	0.00 ±0.00 ^{a}	10.0 ±0.00 ^{b}	0.00 ±0.00 ^{a}	23.3 ±0.33 ^{c}	10.0 ±0.00 ^{b}	0.00 ±0.00 ^{a}	0.00 ±0.00 ^{a}	43.3 ±3.5
	Canola	1	0.00 ±0.00 ^{a}	0.00 ±0.00 ^{a}	0.00 ±0.00 ^{a}	66.8 ±0.87 ^{e}	53.3 ±0.33 ^{d}	20.0 ±0.00 ^{c}	10.0 ±0.00 ^{b}	5.0 ±0.08 ^{b}	155.1 ±12.9
		2	30.0 ± 0.00 ^{c}	0.00 ±0.00 ^{a}	80.0 ±0.00 ^{d}	10.0 ±0.00 ^{bc}	20.0 ±0.00 ^{c}	5.0 ±0.03 ^{b}	20.0 ±0.00 ^{c}	0.00 ±0.00 ^{a}	165.0 ±4.0
		3	0.00 ±0.00 ^{a}	0.00 ±0.00 ^{a}	0.00 ±0.00 ^{a}	0.00 ±0.00 ^{a}	00.0 ±0.00 ^{a}	0.00 ±0.00 ^{a}	10.0 ±0.00 ^{b}	10.0 ±0.00 ^{b}	20.0 ±0.0
	Cabbage	1	0.00 ±0.00 ^{a}	0.00 ±0.00 ^{a}	0.00 ±0.00 ^{a}	36.7 ±0.09 ^{d}	35.0 ±0.50 ^{d}	20.0 ±0.00 ^{c}	6.7 ±0.09 ^{b}	33.4 ±0.33^{d}	131.8 ±10.1
		2	93.3 ±1.50 ^{d}	5.0 ±0.08 ^{b}	70.0 ±0.23 ^{d}	37.6 ±0.50 ^{d}	20.0 ±0.00 ^{b}	5.0 ±0.08 ^{b}	10.0 ±0.00 ^{b}	10.0 ±0.00 ^{b}	245.9±31.3
		3	0.00 ±0.00 ^{a}	0.0 ±0.00 ^{a}	0 .00±0.00 ^{a}	10.0 ±0.00 ^{b}	00.0 ±0.00 ^{a}	10.0±0.00 ^{b}	10.0 ±0.09 ^{b}	0.00 ±0.00 ^{a}	35.0 ±1.0
	Cauliflower	1	0.00 ±0.00 ^{a}	0.00 ±0.00 ^{a}	0.00 ±0.00 ^{a}	36.7 ±0.33^{d}	55.4 ±0.56 ^{e}	20.0 ±0.00 ^{c}	10.0 ±0.00 ^{b}	33.3 ±0.09 ^{d}	155.4 ±9.78
		2	83.3 ±0.00 ^{d}	115.0 ±0.50 ^{e}	30.0 ±0.00 ^{c}	36.7 ±0.00 ^{c}	50.0 ±0.50^{d}	5.0 ±0.05 ^{b}	0.00 ±0.00 ^{a}	0.00 ±0.00 ^{a}	320.0 ±10.8
		3	0.00 ±0.00 ^{a}	0.00 ±0.00 ^{a}	23.3 ±0.00 ^{c}	10.0±0.00 ^{b}	00.0 ±0.00 ^{a}	0.00 ±0.00 ^{a}	10.0±0.00 ^{b}	10.0±0.00 ^{b}	53.3 ±0.0
	Radish	1	0.00 ±0.00 ^{a}	0.00 ±0.00 ^{a}	0.00 ±0.00 ^{a}	6.7 ±0.09 ^{b}	20.0 ±0.00 ^{b}	25.1 ±0.09^{cd}	20.0 ±0.00 ^{c}	26.7 ±0.12 ^{d}	98.5 ±3.2
		2	73.4 ± 0.67 ^{b}	33.3 ±0.33^{c}	130.0 ±3.80	40.0 ±0.00^{d}	00.0 ±0.0 ^{a}	6.7 ±0.30 ^{b}	13.3 ±0.30 ^{bc}	20.0 ±0.00 ^{cd}	316.7 ±19.6
		3	0.00 ±0.00 ^{a}	0.00 ±0.00 ^{a}	0.00 ±0.00 ^{a}	0.00 ± 0.00 ^{a}	20.0 ±0.00 ^{b}	0.00 ±0.00 ^{a}	0.00 ±0.00 ^{a}	0.00 ±0.00 ^{a}	20.0 ±0.0

ǂ1, soil without treatment (zero time); 2, soil during cultivation with different *Brassica* species; 3, soil after Biofumigation process with cultivated plants. Data are in means±SE. Mean values with different Letters per each row are significantly different at p≤0.05 using Duncan's Multiple Range test; *A, Aspergillus; F, Fusarieum.*

highest values. This is due to variations in the amount and type of glucosinolate hydrolyzed compounds produced by different Brassicaceae species. As a result of the biofumigation procedure, these chemicals were released from each plant tissue. According to Lord et al. (2011), Tylor (2013), Charles *et al.* (2015), and Hoshino *et al.* (2015), this explanation is correct (2015).

Furthermore, the results showed that cabbage and cauliflower are successful in reducing the CFU of soil-borne fungi, which may be explained by the high quantity of glucosinolate in cabbage, huge biomass, and high amount of glucosinolate, which is very effective in controlling soil-borne fungi and improving soil quality. Biofumigation with cabbage and cauliflower has been shown to be efficient against Fusarium sp. This finding is consistent with those of Fan *et al.* (2008), Lord *et al.* (2011), and Charles *et al.* (2015).

Cabbage and canola are efficient CFU-supressor (Cal et al., 2005; Smolinska and Kowalczyk, (2014) and Hu *et al.* (2015). These findings demonstrate that BFP is an efficient strategy for controlling soil-borne diseases (Szczyglowska *et al.*, 2011; Charles *et al.*, 2015).

CONCULSION

Biofumigation is an environmentally friendly method of controlling soil-borne diseases**.** Biofumigation using Brassicaceae species improves soil quality and is effective in reducing the CFU of soil-borne fungus. Our approach is to use BFP as an alternative strategy of controlling plant disease and improving soil quality.

REFERENCES

BUI, H., X. AND J. A. DESAEGER. 2021. Volatile compounds as potential bio-fumigants against plant-parasitic nematodes- amini review. Journal of Nematology 53: 1-12. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8039993/pdf/jofnem-53-014.pdf

CAL, A. D., A. MARTINEZ-TRECENO, T. SALTO, J. M. LOPEZ- ARANDA, AND P. MELGAREJO. 2005. Effect of chemical fumi-gation on soil fungal communities in Spanish strawberry nurseries. Applied Soil Ecology 28 (1): 47-56.

CHARLES, K., K. AGATHA, M. RONALD, P. COSMAS, M. LGNITIUS, AND M. BLESSING. 2015. Nematicidal effects of Brassica formulations against root knot nematodes (*Meloidogyne javanica*) in tomatoes (Solanum lycopersicum L.). Pakistan Journal of Phytopathology 27 (2): 109-114.

DEGENS, B. 1998. Decreases in microbial functional diversity do not result in corresponding changes in decomposition under different moisture conditions. Soil Biology and Biochemistry 30 (14): 1989-2000.

FAN, C. M., G. R. XIONG, P. QI, G. H. JI. AND Y. A. HE. 2008. Potential biofumigation effects of *Brassica oleracea* var. *caulorapa* on growth of fungi. Journal of Phytopathology 156 (6): 321-325.

GIMSING, A. L., J. C. SORENSEN, l. TOVGAARD, F. A. M. JORGENSEN, AND H. C. B. HANSEN. 2006. Degradation kinetics of glucoseinolates in soil. Environmental Toxicology and Chemistry 25 (8): 2038-2044.

GIMSING, A. L. AND J. A. KIRKEGAARD. 2009. Glucosinolates and biofumigation: fate of glucosenolates and their hydrolysis products in soil. Phytochemistry Reviews 8: 299-310.

HANDISENI, M., J. YOUNG-KI, L. KYUNG-MIN, AND Z. XIN-GEN. 2016. Screening Brassicaceous plants as biofumigants for management of Rhizoctonia solani AG1-IA, Plant Disease 100 (4): 258-263.

HANSCHEN, F.S., B. YIM, T. WINKELMANN, K. SMALLA. AND M. SCHREINER 2015. Degradation of Biofumigant Isothiocyanates and Allyl Glucosinolate in Soil and Their Effects on the Microbial Community Composition. PLOS ONE 10 (7): 1-18. e0132931. https://doi.org/10.1371/journal.pone.0132931.

HANSCHEN, F. S., AND T. WINKELMANN. 2020. Biofumigation for fighting for replant disease- a revie. Agronomy 10 (425): 1-16. doi:10.3390/agronomy10030425. https://www.mdpi.com/journal/agronomy

HOSHINO, Y. T. AND N. MATAVERAGEOTO. 2007. Change in fungal community structure in bulk; soil and spinach rhizosphere soil after chemical fumigation as revealed by 18S rDNA PCR-DGGE. Soil Science and Plant Nutrition 53: 40-55.

HU, P., E. B. HOLLISTER, A. C. SOMENAHALLY, F. M. HONS, AND T. J. GENTRY. 2015. Soil bacterial and fungal communities respond differently to various isothiocyanates added for biofumigation. Frontiers in Micrbiology/ Terrestrial Microbiology, (5); Articles 729: 1-9 https://www.frontiersin.org/article/10.3389/fmicb.2014.00729.

HANDISENI, M., J. YOUNG-KI, L. KYUNG-MIN, AND Z. XIN-GEN. 2016. Screening Brassicaceous plants as biofumigants for management of Rhizoctonia solani AG1-IA, Plant Disease 100 (4): 258-263.

HANSCHEN, F.S., B. YIM, T. WINKELMANN, K. SMALLA. AND M. SCHREINER 2015. Degradation of Biofumigant Isothiocyanates and Allyl Glucosinolate in Soil and Their Effects on the Microbial Community Composition. PLOS ONE 10 (7): 1-18. e0132931. https://doi.org/10.1371/journal.pone.0132931.

HANSCHEN, F. S., AND T. WINKELMANN. 2020. Biofumigation for fighting for replant disease- a revie. Agronomy 10 (425): 1-16. doi:10.3390/agronomy10030425. https://www.mdpi.com/journal/agronomy.

HOSHINO, Y. T. AND N. MATAVERAGEOTO. 2007. Change in fungal community structure in

bulk; soil and spinach rhizosphere soil after chemical fumigation as revealed by 18S rDNA PCR-DGGE. Soil Science and Plant Nutrition 53: 40-55.

HU, P., E. B. HOLLISTER, A. C. SOMENAHALLY, F. M. HONS, AND T. J. GENTRY. 2015. Soil bacterial and fungal communities respond differently to various isothiocyanates added for biofumigation. Frontiers in Microbiology/ Terrestrial Microbiology, (5); Articles 729: 1-9 https://www.frontiersin.org/article/10.3389/fmicb.2014.00729.

JAIME-GARCIA, R., A. Z. TUCSON, AND P. J. COTTY. 2006. Crop rotation influences aflatoxin producing potential of Aspergillus. communities South Texas, Beltwide Cotton Conferences, San Antonio, Texas, January 3-6: 60-64.

KRUGER, D. H. M., J. C. FOURIE, AND A. P. MALAN. 2013. Cover crops with biofumigation properties for the suppression of plant- parasitic Nematodes; a review, South African Journal of Enology and Viticulture. 34 (2): 287-295.

KUMAR, P. 2005. Biofumigation, concept notes and compilation of session guides on Biofumigation, Inter-country Programme for Vegetable IPM in South and SE Asia Phase II, Food and Agriculture Organization of the United Nations: 1-34.

LORD, J. S., L. LAZZERI, H. J. ATKNSON, AND P. E. URWIN. 2011. Biofumigation for control of potato cyst Nematodes: Activity of Brassica leaf extracts and green manures on Globodera pallida in vitro and in soil, ©American Chemical Society, Journal of Agriculture and Food Chemistry 59: 7882- 7890.

MOTSARA, M. R. AND R. N. ROY. 2008. Guide to laboratory establishment for plant nutrient analysis, Food and Agriculture Organization of the United Nation, Rome. FAO Fertilizer and Plant Nutrition Bulletin 19: 1-219. ISBN 978-92-5-105981-4.

NTALLI, N. AND P. CABONI. 2017. A review of isothiocyanates biofumigation activity on plant parasitic Nematodes, Phytochemistry Reviews 16: 827-834. DOI 10 1007/S 11101-017-9491-71-8.

OMIROU, M., C. ROUSIDOU, F. BEKRIS, K. K. PAPADOPOULOU, U. MENKISSOGLOU-SPIROUDI, C. EHALIOTIS, AND D. G. KARPOUZAS. 2011. The impact of biofumigation and chemical fumigation methods on the structure and function of the soil microbial community. Microbial Ecology 61: 201-213.

PARASAD, P., J. KUMER, AND S. PANDEY. 2015. Biofumigation: Success and prospects in soil-borne plant disease management. International Journal of Applied and Pure Science and Agriculture 1 (6): 47-60. @IJAPSA-2015. www.ijapsa.com

REDDY, P. P. 2011. Biofumigation and Solarization for management of soil-borne plant pathogens. Book, Sentific, India Pp: 431. ISBN-10: 8172336977.

ROUBTSOVA, T., J. A. LOPEZ-PEREZ, SEDWARD, AND A. PLOEG. 2007. Effect of Broccoli (Brassica oleracea) tissue, incorporated at different depths in a soil column, on Meloidogyne incognita, Journal of Nematology 39 (2): 111-117.

RUDOLF DE BOER, J. PETKOWSKI, T. WICKS, R. HARDING, AND A. WATSON. 2001. Influence of rotation and biofumigation on soil-borne disease of potatoes. Horticulture Australia, Project Number: PT96032: 1-110. www.nre.vic.gov.au/ihd.

SARHAN, E. A. D., EL-SAYED, S. A., H. M. ABD-ELMAKSOUD AND T. S. ELMAR-SAFAWY. (2020). Influence of biofumigation with Mustard or Canola seed meal in controlling soil-borne pathogenic fungi of Chickpea. Egyptian Journal of Agricultural Research, 98 (1): 40-51.

SMOLINSKA, U. AND W. KOWALCZYK. 2014. The impact of the Brassicaceae plant materials ADDEC to the soil on the population of Fusarium solani (Mart.) Sacc. and Fusarium oxysporum Schlecht. Journal of Horticulture Research 22 (1): 123-129.

SRIVASTAVA, J. N. AND A. GHATAK. 2017. Biofumigation: A control method for the soil-borne diseases. International Journal of Plant Protection 10 (2): 453-460.

SUHAIL, M., S. AKHUND, T. JATT, A. M. MANGRIO, AND H. ABRO. 2006. Isolation and identification of Penicillium spp., from the river Indus Bed at Kotri. Pakistan Journal of Botany 38 (4): 1289-1292.

SZCZYGLOWSKA, M., A. PIEKARSKA, P. KONIECZKA, And J. NAMIESNIL. 2011. Use of Brassica plants in the Phytoremediation and Biofumigation processes, International. Journal of Molecular Sciences 12 (11): 7760-7771.

TAYLOR, F. I. 2013. Control of soil borne potato pathogens using Brassica spp. mediated biofumigation. PhD thesis, University of Glasgow, I-XIV+1-186.

WANG, G., M. NGOUAJIO, AND K. S. CHARLES. 2010. Brassicaceae biofumigants improve Onion (*Allium cepa*) and Celery (*Apium graveolens*) production systems. Journal of Sustainable Agriculture 34: 2-14.

WANG, Q., Y. MAY, H. YANG, AND Z. CHANG. 2014. effect of biofumigation and chemical fumigation on soil microbial community structure and control of Pepper Phytophthora blight. World Journal of Microbial Biotechnology 30 (2): 507-518, abstract.

YIM, B., F. S. HANSCHEN, A. WREDE, H. NITT, M. SCHREINER, K. SMALLER, AND T. WINKELMANN. 2015. Effect of biofumigation using Brassica juncea and Raphanus sativus in comparison to disinfection using Basamide on apple plant growth and soil microbial communities at three field sites with replant disease. Plant Soil, DOI 10.1007/S11104-016-2876-3, ©Springer International Publishing Switzer Land pp.:1-20.

تأثير التبخير الحيوي بنباتات Brassica على عدد وتنوع الفطريات التي تنقلها التربة في مدينة العريش، مصر

منجه ابراهيم موسي
كلية العلوم قسم النبات والميكروبيولوجى، حى الضاحية، جامعة العريش، العريش، جمهورية مصر العربية

الملخص العربـــــي

تم دراسة التبخير الحيوى بواسطة اجناس مختارة من العائلة الصليبية (اللفت, الجرجير، الكانولا، الكرنب، الارنبيط و الفجل) لمعرفة تاثيرها علي خواص التربة وكذلك العدد الكلي للقطريات ونوع الاجناس الموجوده، أوضحت التجارب الحقلية تاثير التبخير الحيوى على تحسين خواص التربة و زيادة مقدرة التربة على الاحتفاظ بالماء و النسبة المؤية للمواد العضوية والكربون العضوى. كما اوضحت التجارب ان اعلى نسبة للمواد العضوية (2.03 و 2.45%) والكربون العضوي (1.19 و 1.42%) عند استخدام نبات الكانولا ونبات الارنبيط بالتتابع، وقد لوحظ تاثير عملية التبخير الحيوى على متوسطات عدد المستعمرات للفطريات المعزولة/ ملليتر من محلول التربة وكذلك التاثير على تنوع الفطريات داخل التربة. ويتضح من النتائج بان العدد الكلى لمتوسطات المستعمرات الفطرية قد تراجع بشكل معنوي بعد القيام بعملية التبخير الحيوى مقارنة بعينات الكنترول. كما سجلت النتائج زيادة لاعداد متوسطات المستعمرات اثناء نمو المعاملات النباتية بالتربة. ولذلك تاثير عملية التبخر الحيوي ذات تاثير قوي ومعنوي علي الاعداد الكلية للمستعمرات الفطرية. كما وجدن الدراسة ان فطر الفيوزاريم لاتيريتيوم تناقص بشكل معنوي بعد القيام بالتبخير الحيوى. مقارنة بالكنترول وكذلك اثناء نمو الأنواع المختارة وبعد عملية التبخير الحيوي.. ومن خلال الدراسة لتاثير التبخير الحيوى، بواسطة اجناس من العائلة الصليبية، نلاحظ مدي التحسن لصفات التربة وكذلك ظهور لبعض اجناس الفطريات واختفاء لاجناس اخرى. واثيتت الدراسة، تحت الظروف الحقلية لمكان الدراسة، ان نبات الكانولا والفجل والكرنب من اقوي النباتات المؤثرة علي قيم المتوسطات وحدات عد المستعمرات الفطرية المسببة للامراض النباتية.