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Original Research Article

The impact of organophosphorus pesticide on *Solanum melongena*, *Capsicum annum* and Soil

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Abstract

Eggplant (*Solanum melongena*) and green chilli (*Capsicum annum*) are an important vegetables crop grown throughout the year in the India. However, these vegetables crops suffer heavily from the ravages of various insect pests and disease, which reduce not only the yield but also the quality of the fruit. Malathion is part of the widely used insecticides all around the world. The present study emphasizes the effect of various concentrations and exposure periods of an organophosphorus pesticide. Malathion on two very important vegetative crops eggplant (*Solanum melongena*) green chilli (*Capsicum annum*). This study was performed at the department of environmental studies, Integral University, Lucknow (U.P.). The effect of Malathion on growth of the two vegetable crops was observed under greenhouse condition. Sampling of eggplant and green chilli were grown in assorted sets with 2, 4 & 6 ml/L foliar treatment of Malathion. Two sets of control plants were grown without Malathion treatment. They were harvested after 7 & 14 days. Experimental observation revealed that low concentration of Malathion had synergistic effect while higher level had an adverse effect on growth of plant and soil properties. This study infers that whereas lower levels are beneficial. Higher level of pesticides should be avoided and special care be taken to prevent their entry in the food chain.

Keywords: Malathion, Pesticides, Environmental pollution, Vegetative crops

Introduction

Fruit and vegetables are important components of the human diet since they provide various nutrients essential for our body. Their quality and yield are influenced by attacks of pests during their production and storage, leading to a huge loss. With revolutionary advancements in agricultural practices during the last few decades, use of pesticides has largely increased worldwide to protect crops from pest and diseases and increase agricultural yield for rapidly growing global population (Abhilash et al., 2009; Fenner et al., 2013), but their excess and indiscriminate use had adverse effects on growth, yield and quality of crops. Due to extensive use of pesticides across the world since 1950, most of the agricultural land is contaminated (Singh et al., 2012). Harmful effect of pesticide is part of the major factors responsible for reduced yield, especially for most sensitive horticultural crops, the vegetables. Reduced yield due to pests is common all over the world including India, where crop losses are nearly 40% under normal condition (Yuya, 2014). However, lack of awareness regarding pesticide use has led to environmental pollution, including contamination of soil and underground water (Nasrabadi et al., 2011). Currently, among the various groups of pesticides used all over the world, organophosphates from a major group and extend to more than 36% of the total world market (Kanekar et al., 2003). Organophosphates have gradually replaced organochlorine for pest control and higher crop yields. Chemically, organophosphates are esters of phosphoric acid and used to control a variety of insects, spiders, mites, aphids and pests which attack

crops like tobacco, sugarcane, cotton, fruit, vegetables and ornamentals (Gafar et al., 2013).

Malathion [S-(1,2- dicarbethoxyethyl) -O, O-dimethyl dithio-phosphate], also known as carbophos, maldison and mercaptothion is a non-systemic, wide-spectrum organophosphorus pesticide used in agricultural settings (Srinivas et al. 2016). It is commonly used for the control of sucking and chewing insects of fruit and vegetables, mosquitoes, flies, household insects, animal parasites (ectoparasites). Malathion is largely used for public health and agricultural purposes (Singh et al., 2013)

Nevertheless, Malathion is a highly toxic compound and is indicated by the United State Environmental Protection Agency (USEPA) as toxicity class (Group 2A). It is considered to be carcinogenic to humans and animals. Its high-level exposure will affect nerve fibers and is neurotoxic in animals and affect immunity of higher vertebrates (Rai et al., 2016). Malathion is not supposed to be toxic to plants or aquatic algae because its mode of action targets only nervous systems (Qing et al., 2009). However, in humans, Malathion toxicity can be exerted via skin contact, ingestion, and inhalation exposure (Vasiliki et al., 2007). In South Africa, researchers found negative results of Malathion on Alfalfa, Maize and watermelon. Pesticide's effect on soil was investigated by many researchers (Aktar et al., 2009). Some study reported a decrease in some nutrients in soil, mainly heavy minerals and increase in phosphorus level due to the application of Malathion (Gafar et al., 2014). Ahmed et al. (2011) reported the negative effect of the pesticide on wheat growth. Srinivas et al., 2016 considered the effect of different concentrations of Malathion on protein and chlorophyll content of Green gram and Fenugreek. Similarly, Saleh et al., 2006 reported the comparative effect of Malathion and Mancozeb on growth parameters of Zea mays and Viciafaba under the presence or absence of mycorrhizal, inoculation.

In the present study, two widely used vegetable crops in India such as Eggplant (*Solanum melongena*) and green chilli (*Capsicum annum*) were selected. These are the principal vegetable crops grown in India. However, both of them are susceptible to pests and diseases. Farmers use higher amounts of pesticides than recommended doses because of ignorance, lack of training, experience, awareness etc. (Sabur et al., 2001). They also have the mistaken notion that over application of pesticides will enhance the plant growth and yield. Hence, they utilize excess pesticides. On the basis of higher pesticides use. These vegetative plants were chosen for this study. They were treated with foliar application of Malathion under the controlled conditions in a greenhouse. The effort was to assess the effect of Malathion on plant growth and soil.

Material and Methods

Experiment layout

The experiment was conducted at the experimental field of Integral University (Lucknow, Uttar Pradesh 26.9585°N,80.9992°E). Garden soil, with no previous insecticide history, was collected from the university campus, for pot culture experiment. Larger particles were removed from the soil for homogeneity. 2kg garden soil was filled in earthen pots. Eight sets of pots were taken in triplicate for each sampling day. Among this, six sets of vegetable crops (three sets each of eggplants and green chilli) were treated with three different concentrations of Malathion 2, 4, and 6 ml L-1. Remaining two sets were kept as control (pots with control eggplants and green chilli plants) without any treatments. The two vegetable crops are Eggplant (*Solanum melongena*) and green chilli (*Capsicum annum*) were grown in the nursery tray before being transplanted to the experimental pots. Different concentration of Malathion (EC-50%) was applied by foliar spray at the stage when leaves overspread. All pots were watered daily and growth variables such as root length, shoot length and growth rate were recorded periodically.

Growth analysis of plants

Plant samples were collected periodically and washed with tap water to remove the soil particles. Shoot length, root length, no. Of leaves and leaf area of collected sample was recorded.

Physico-chemical analysis of soil

The pH was measured in soil–water suspension using cyberscan 500 pH meters; electrical conductivity (EC) was measured using cyberscan 500 EC Meter. Soil potassium was measured using flame photometer (systronics 128). Total nitrogen was determined using the Kjeldahl method and available phosphorus was determined by the method of Olsen (Anderson et al., 1994).

Results

Growth performance of *Solanum melongena* and *Capsicum annum*

Effect of Malathion on growth of eggplant and green chilli is shown in Fig.1A and Fig.2A respectively, and their relative growth levels compared with the respective control plants are depicted in Fig. 1B and Fig. 2B. There was significant difference in growth of plants with low and higher concentration of Malathion and exposure periods.

Figure 1-A: Growth response of eggplants grown at three different Malathion concentrations (ml L^{-1})

Figure - 2-A: Growth response of green chilli grown at three different Malathion concentrations (ml L^{-1})

Thus from Fig. 1A and 1B, we can see that, 7days after the application of pesticide, at 2 ml L^{-1} concentration, the growth parameters (root length, shoot length, no. of leaves and leaf area) of eggplant increased as compared to other concentrations (i.e. 4 and 6 ml L^{-1}) and control. At 4 ml L^{-1} concentration, the growth parameters increased as compared to control and then decreased at 6 ml L^{-1}. After 14 days, the root and shoot length were increased in 2 ml L^{-1} and decreased in control, 4 ml L^{-1} and 6 ml L^{-1}L. The overall changes in root and shoot length in response to various concentrations of Malathion treatments were in the order of 2 ml L^{-1}> control > 4 ml L^{-1}> 6 ml L^{-1}. Similarly, the leaf area was highest at 2 ml L^{-1} but lower at 6 ml L^{-1} concentration and but increased in 4 ml L^{-1} and control plant (2 ml L^{-1}> 4 ml L^{-1}> control > 6 ml L^{-1}). whereas at 6 ml L^{-1}, the number of leaves increases as compared to control and 4 ml L^{-1} concentration (2 ml L^{-1}> 6 ml L^{-1} > control > 4 ml L^{-1}). The visual symptom was seen in fig. 1A that the plant leaves of eggplant were yellowish in colour at 4 and 6 ml L^{-1} concentration and also in control plant. *Capsicum annum* has better growth response in comparison with that of *Solanum melongena*. There was no visual symptom seen in chilli plant except the reduction in plant height and total number of leaves. After 7th day the growth parameters increased at 2 ml L^{-1} concentration compared to other concentrations and control. On day 14th, the root length of chilli plant recorded better result in 2 ml L^{-1} concentration. Barr et al. (2006) studied the effect of Malathion on tomato. He found that there Malathion has little or no effect on plant height but strongly affected the root system. The root length and no. of leaves also increased at 6 ml L^{-1}. But the leaf area was decreased at 6ml L^{-1} concentration and increased at 2 ml L^{-1} and 4 ml L^{-1}concentration. This reveals that Malathion has significant effect on growth of both chilli and eggplant. Both the figures show that, during 7th day of exposure, all the growth parameters were positively affected by lower concentration (2 ml L^{-1}) of Malathion. However, with control plant and with higher levels (4 & 6 ml L^{-1}) of Malathion and increasing exposure days, growth parameters viz. root length, shoot length and foliage were declined. A study revealed a positive effect of Malathion on radish growth at lower concentration and negative effect at higher concentrations (Dennis et al., 1999). Gafar et al. (2014) also found positive effect of Malathion on carrot plant at lower levels and negative effect at higher doses. There is no significant difference in growth parameters with higher dose and control plants.

Physico-chemical properties of soil

Soil quality changes after the addition of Malathion in test plants at various exposure days is presented in Table - 1. The effect of Malathion addition to the soil of test plants was variable.

The total nitrogen content, extractable phosphorous and potassium were higher in soil before planting. Before the addition of Malathion, soil had pH 7.37 ± 0.3, electrical conductivity (EC) 1.34 ± 0.11, total nitrogen percentage 0.009 ± 00.3, available phosphorus 6.91±0.99 ppm and potassium 36.11 ± 0.99 ppm

Soil pH

In eggplant, the soil pH was highest in control (7.34 ± 0.4) and slightly reduced with increasing concentration of Malathion (2 ml L^{-1}, 4 ml L^{-1}, and 6 ml L^{-1}). After 14 days, the soil pH was maximum in control (7.31 ± 0.6), and minimum in 6 ml L^{-1}(7.14 ± 0.2) concentration. It was increase in 2 ml L^{-1}(7.26 ± 0.5) compared to 4 ml L^{-1}(7.22±0.8). In green chilli plant, soil pH was maximum in control experiment and was slightly reduced with increasing concentration of Malathion (2 ml L^{-1}, ml L^{-1}, and 6 ml L^{-1}) at both harvesting days (day 7 and day14).

Electrical conductivity

On day 7 and day 14, the electrical conductivity was minimum in control and maximum in 2 ml L^{-1} and slightly decreased with increasing concentrations for both plant species.

Total nitrogen

From table 1, after the application of pesticide at day 7, the total nitrogen was maximum in 2 ml L^{-1}(0.021 ± 0.05, 0.025 ± 0.08) and minimum in control (0.006 ± 0.01, 0.009 ± 00.3).

There was no significant difference in 4 ml L^{-1}(0.013 ± 0.004, 0.016 ± 0.03) and 6 ml L^{-1}(0.011 ± 0.01, 0.017 ± 0.12) for eggplant and green chilli respectively. At day 14, the same trend was found for both plants.

Available phosphorus

For eggplant, at day 7, the available phosphorus was higher in 2 ml L^{-1}(6.21±1.55) and reduced with 4 ml L^{-1} (6.12 ± 1.95), 6 ml L^{-1}(6.02 ± 0.93) and control (6.05 ± 0.86). On 14th day exposure, phosphorus was maximum in 2 ml L^{-1}(6.54 ± 1.38) whereas minimum in control plants (6.19 ± 0.69). But in the case of chilli plants, phosphorus was maximum in 2 ml L^{-1}(6.88 ± 0.93, 7.31 ± 0.99) and minimum in control (6.01±.731, 6.42 ± 0.64) for 7 and 14 day.

Potassium

Potassium was maximum in 2 ml L^{-1} (33.60 ± 1.08, 40.72 ± 1.48) and minimum in control (28.43 ± 2.24, 30.88 ± 2.03) with intermediate levels at 4ml/L (32.26 ± 2.01, 36.69 ± 2.00) and 6 ml L^{-1} (29.01 ± 1.82, 35.65 ± 3.39) concentration for day 7 and 14, respectively, in eggplant. However, in chilli, it was maximum in 2 ml L^{-1} (36.58 ± 3.24, 38.32 ± 3.54) whereas minimum in control (29.41±2.06, 29.52±1.47) but no significant difference in 4 ml L^{-1} (33.84 ± 1.09, 41.78 ± 5.24) and 6 ml L^{-1} (34.32 ± 1.76, 41.04 ± 0.62) was observed.

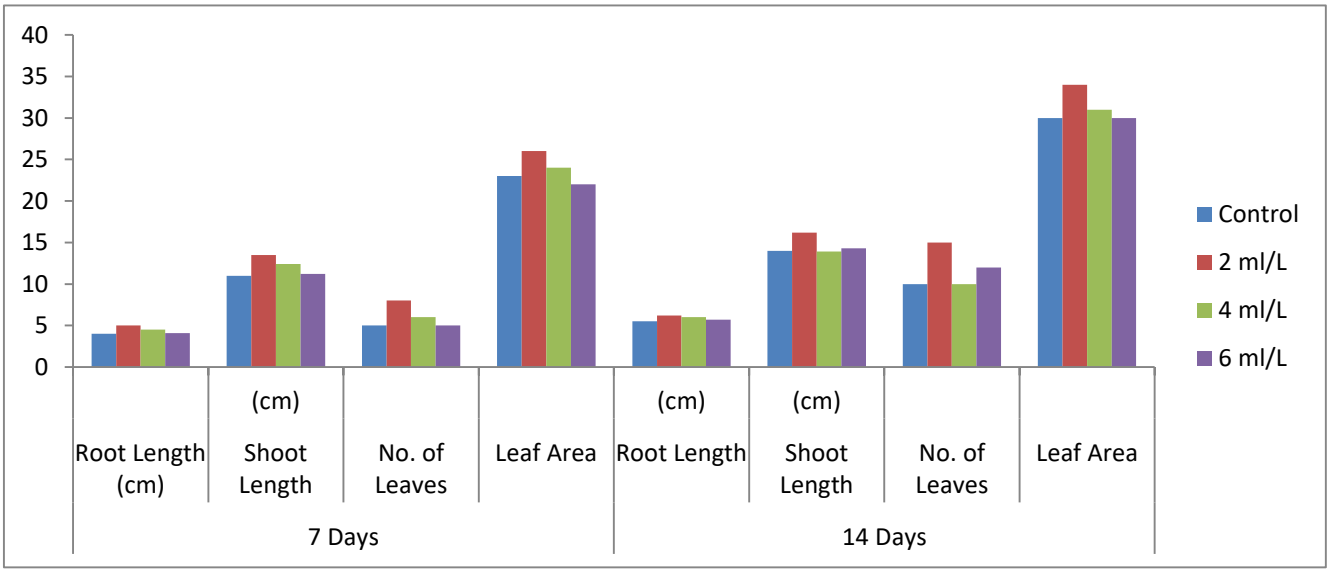

Figure - 1-B: Growth response of eggplant during Malathion exposure

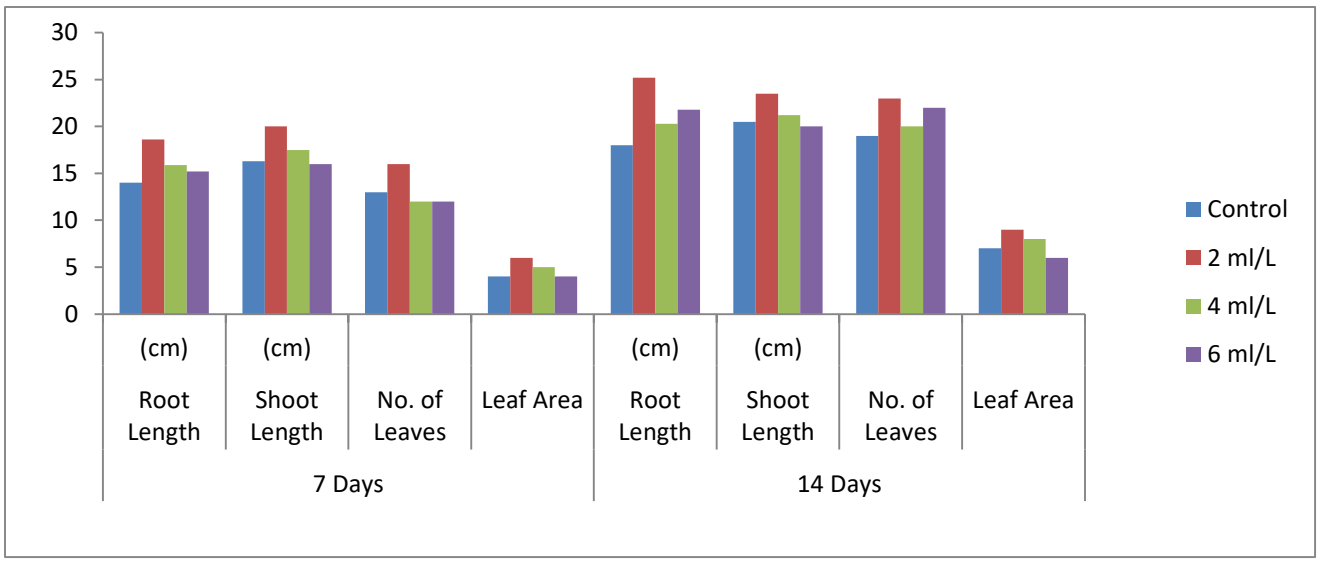

Figure - 2-B: Growth response of Chili Plant during Malathion exposure

Table – 1: Changes in soil quality after the addition of Malathion

Malathion concentration	Eggplant									
	Total Nitrogen (%)		Available Phosphorus (ppm)		Potassium (ppm)		pH		EC	
	7 days	14 days	7 days	14 days	7 days	14 days	7 days	14 days	7 days	14days
Control	0.006±0.01	0.012±0.003	6.05±0.86	6.19±0.69	28.43±2.24	30.88±2.03	7.34±0.4	7.31±0.6	0.92±0.1	0.95±0.05
2 ml L^{-1}	0.021±0.05	0.027±0.02	6.21±1.55	6.54±1.38	33.60±1.08	40.72±1.48	7.23±0.5	7.26±0.5	1.15±0.1	1.04±0.09
4 ml L^{-1}	0.013±0.004	0.022±0.005	6.12±1.95	6.29±0.99	32.26±2.01	36.69±2.00	7.23±0.2	7.22±0.8	1.09±0.8	1.00±0.3
6 ml L^{-1}	0.011±0.01	0.020±0.004	6.02±0.93	6.27±2.04	29.01±1.82	35.65±3.39	7.21±0.2	7.14±0.2	1.01±0.4	0.96±0.6
Green chilli Plant										
Control	0.009±00.3	0.017±0.11	6.01±1.73	6.42±0.64	29.41±2.06	29.52±1.47	7.32±0.09	7.33±0.5	0.96±0.07	0.99±0.02
2 ml L^{-1}	0.025±0.08	0.031±0.01	6.88±0.93	7.31±0.99	36.58±3.24	38.32±3.54	7.26±0.28	7.28±0.61	1.21±0.02	1.08±0.01
4 ml L^{-1}	0.016±0.03	0.025±0.003	6.43±0.88	6.98±1.39	33.84±1.09	41.78±5.24	7.24±0.03	7.27±0.01	1.16±0.04	1.13±0.08
6 ml L^{-1}	0.017±0.12	0.021±0.013	6.08±1.92	6.79±1.02	34.32±1.76	41.04±0.62	7.18±0.01	7.21±0.7	1.15±0.09	1.07±0.04

Discussion

The results of the present study have revealed that a higher dose of Malathion on test plants has affected the growth response of both eggplant and green chilli and also altered the soil properties. In general, low level of Malathion gave better results than higher doses and control plant. Gafar et al., 2014 also found a positive effect of Malathion on carrot plant at lower levels and negative effect at higher doses. There is no significant differences in growth parameters of higher dose and control plants.

pH and EC were not affected that much by the addition of different doses of Malathion but total nitrogen, available phosphorus and potassium were significantly affected with increasing concentration of Malathion (i.e. from 2 to 6 ml L-1) and exposure days. The physico-chemical properties of soil viz. total nitrogen, phosphorus and potassium gave a better result in *Capsicum annum* compared to *Solanum melongena* that's why *Capsicum annum* has better growth response than *Solanum melongena*. Walia et al., 2018 studied the effect of Chlorpyrifos and Malathion on soil microbial population and enzyme activity and he found that the lower concentration of Malathion and chlorpyrifos is beneficial but higher concentration lead to reduction in microbial action in soil, which is also responsible for plant growth. Similar results were obtained by researchers who stated that Sevin pesticide reduce the activity of microorganisms which lead to the reduction of the absorption of some minerals, especially, in garden rocket plant (Elbashier et al., 2016). He also concluded that the stability of pesticides in soil depends on the nature of pesticides, especially their concentration, solubility and evolution in the air. It is reported that pesticides reduce absorption of some trace elements (Fe. Zu) and affect the viruses found at the root zone of the garden rocket

plant which reduce their tolerance to some diseases (Mohanty et al., 2013).

Conclusion

The study explored the effect of Malathion on eggplant and green chilli plants in greenhouse condition. The experimental results revealed that the excessive amounts of Malathion on vegetative crop distorted the soil properties and also the growth response of eggplant and green chilli. It is clearly seen that the higher doses of Malathion are deleterious to plant growth and soil properties, but lower or recommended dose is helpful to enhance the growth of plants and soil properties compared to control. Therefore, the wise and judicious use of Malathion will not only help in killing pests, but also, improves the soil quality and vegetable production. However, more studies are required to elucidate the fate and behaviour of Malathion in different kind of vegetables and soil.

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