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Effect of Some Pesticides on Seed Germination of Selected Vegetables

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ABSTRACT

Background and Objective: Pesticides are highly toxic substances. Their toxicity may not be absolutely specific to the target organisms but can adversely affect different processes in the non-target host plants. The main objectives of this research were to know about the concentration-dependent effect of these pesticides on seed germination, to investigate potential differences in sensitivity among different vegetable crops, and to find optimal pesticide concentrations for maximum germination.

Materials and Methods: The study was conducted in the laboratory of the Department of Environmental Sciences, COMSATS University Islamabad-Vehari campus. Seeds of different vegetables (Radish, Turnip, Green beans, Okra, and Brinjal) were procured from an authenticated source with no apparent infection or damage. The seeds were treated with various concentrations of pesticide solutions (Atrazine and Bifenthrin), including control (0 ppm), 1, 10 and 25 ppm, with three replications to observe their growth-promoting or inhibiting effects. A total of 120 plastic boxes were used, divided into two units (each with 60 boxes), in a factorial design with 2-way interaction. Data were collected for different parameters, including seed germination, seedling growth, and seedling length.

Results: The results indicated that seed germination was increased by the application of different pesticides. All the tested pesticides reduced the growth of different vegetable seeds when applied in higher concentrations than the recommended dose, but at lower doses, the pesticides showed stimulatory effects on growth compared to the control.

Conclusion: Pesticides, while generally toxic, can have concentration-dependent effects on vegetable seeds. Lower concentrations of pesticides may stimulate germination and growth, whereas higher concentrations inhibit growth and reduce seedling development.

INTRODUCTION

Pesticides are generally hazardous agents, which may be chemical substances, chemical mixtures, or living organisms, developed to suppress or eliminate specific weeds, rodents, fungi, insects, and other undesirable pests. Pest management strategies for different pest groups involve the application of insecticides, herbicides, fungicides, rodenticides, molluscicides, and nematicides[1]. Reducing the toxicity of pesticides is particularly challenging, as they are typically polar, water-soluble, and thermally stable compounds. Their use poses significant risks to individuals engaged in agriculture and contributes to toxicological hazards in industrial sectors and other environments where pesticides are widely applied. Depending on the targeted species, pesticides may also exert detrimental effects on various environmental components, including natural flora, wildlife, and aquatic ecosystems[2].

Approximately 4.6 million tonnes of chemical pesticides from various manufacturers are applied annually, with nearly 85% used on crops and the remaining 15% employed for other purposes[3], . Chemical pesticides are therefore widely utilised to protect crops by eliminating pests . Global dependence on pesticides has continued to increase, with an estimated annual consumption of 5.2 billion pounds. While chemically derived pesticides have been effective in controlling crop losses caused by insect infestations, they have also generated several adverse environmental impacts. Seed treatment with pesticides enhances crop yield, improves seed quality and provides protection against pests and diseases.

The term “pesticides” refers to substances applied to plants for the management of pests, weeds and diseases, as well as for purposes related to human and animal health. Pesticides encompass several categories, including fungicides, insecticides, nematicides, herbicides, rodenticides, molluscicides, and plant growth regulators. Globally, millions of tonnes of pesticides are applied each year . Insecticides are specifically developed to control or eliminate insect infestations and are further classified into several subclasses, such as neonicotinoids, carbamates, pyrethroids, and organophosphates[1] . Herbicides are used to suppress or eradicate unwanted grasses and plants and are commonly employed in agriculture, forestry, and landscaping[11]. Rodenticides are formulated to control rodents such as rats and mice, which can damage crops and structures and also pose health risks, their use is widespread in both urban and rural settings[12]. Nematodes, microscopic roundworms capable of damaging plant roots and reducing crop yields, are managed through the application of nematicides, which are specifically designed to suppress or eradicate them[13].

Ancient civilizations such as the Sumerians and Egyptians used natural chemicals to preserve their crops from pests and diseases. Synthetic pesticides were first developed in the nineteenth century. Pyrethrum, an insecticide, was discovered from chrysanthemum flowers in 1867. Later, in 1939, DDT (dichlorodiphenyltrichloroethane) became known and widely utilized during World War II[14]. Pesticide use in agriculture, public health, and domestic applications increased rapidly after WWII. Pesticides were important in reducing insect-borne diseases like malaria and typhus, as well as protecting crops from pests and diseases. The book Silent Spring raised awareness of the potential harm caused by pesticides, especially DDT, to wildlife and ecosystems[15]. Pesticides' harmful effects prompted strict laws and the establishment of organizations such as the United States Environmental Protection Agency (EPA) in 1970[16].

Heavy pesticide use has been linked to increasing harmful residual levels in food products, pollution of various environmental sectors, harm to flora and wildlife and contamination of different environmental sectors[17,18]. Pesticide toxicity can affect non-target organisms in the environment in addition to the intended target organisms[19]. Use of pesticides can also destroy soil and water microfauna and plants[20,21]. The use of pesticides in agriculture has significant issues for the environment and human health, which not only cause accumulation of pesticide in soil and crop and id responsible for alteration in biochemical processes undergoing in a plant. Plant activities like development of cell, photosynthesis, biochemical reactions, respiration and molecular composition can all be altered by the usage of pesticides[22]. Excessive and irresponsible pesticides usage inhibits plant and animal growth, produces pests that are more resistant to them, left residue on vegetables and fruits, destroys biodiversity also degrades ecosystems[23]. It may harm seeds and obstruct normal germination, growth, and development processes. Some chemicals can also weaken seeds' viability and prevent them from sprouting[24]. Several research have looked into the negative effects posed by the usage of pesticides, on non-target creatures, particularly mammals, but few have looked into the toxicity of pesticides to non-target plants[25].

Pakistan makes extensive use of a variety of pesticides, much as other regions in the world. Estimates place Pakistan's annual use of pesticides at over 70,000 tonnes, with usage growing at a rate of around 6% per year. Pakistan's unplanned and excessive use of pesticides has drawn criticism[26,27]. Pesticides are employed on crops in around 85% of cases, with the remaining 15% going to other purposes[3]. Almost 89% of the energy used in Pakistan is used in the province of Punjab, Khyber Pakhtunkhwa (2%), Baluchistan (1%) and Sindh (8%), Most farmers in developing countries are uneducated and have little to no pesticide experience. The fact that pesticide suppliers often lack expertise and recommend applying twice or three times the permitted number of pesticides is even more alarming[28]. Even in the absence of a host, seeds make a good home for harmful germs. Such seeds can be protected from fungi, nematodes, and other pests by being treated with fungicides or bacteria[29]. The growth of any crop depends on seeds germination and seedling development[30,31]. It is a critical stage that determines the establishment and productivity of crops in agriculture.

Seed germination is affected by various factors, including temperature, water, oxygen, light, and different hormones and chemicals[32]. The temperature impacts how well seeds germinate, different plant species have different optimal temperature ranges[33]. Water availability must be sufficient for seed germination since it activates enzymes and starts metabolic processes[34]. Several seeds require specific light conditions for germination, Light can promote and restrict the germination process depending upon type of plant[35]. Seed dormancy, a time when germination is inhibited even in ideal conditions, can be impacted by a number of variables, including seed coat impermeability, physiological factors and chemical inhibitors[32].

Pesticides can harm seed germination by directly suppressing or affecting seeds and embryos. In addition, pesticides can disturb the symbiotic interactions between seeds and beneficial microbes, limiting germination and seedling development[36]. Microorganisms in the soil act essential roles in seed germination, such as increasing nutrient availability and protecting against bacterial infections. Pesticides may reduce the diversity and number of beneficial microorganisms, resulting in soil ecosystem imbalances and reduced germination rate[36]. Pesticides can build over time, causing chronic exposure to seeds, resulting in lower germination potential and seedling strength[36].

Numerous researchers have provided their opinions on the advantages and disadvantages of pesticide use. Pesticide residue is a prevalent issue because of the significant effect pesticides have on agricultural plant germination and growth. Agriculture is the primary use for fungicides, nematicides, insecticides, rodenticides, herbicides, molluscicides, and growth hormones[37]. Two uses where seeds are thought to be useful are spraying and seed dressing. Due to the lack of a host, dangerous bacteria are immune to pests and disease organisms even in seeds and seedlings. Fungicide, nematicide, and bactericide treatment may avoid difficulties caused by seed fungus, nematodes, and other pests that are more likely to create issues during germination and growth[29]. Fungicide-treated vegetables, accumulated residues, and crop seeds will all be safeguarded from pesticide usage in the future. fungus that thrives in the soil and cause disease. Only pesticides may induce root rot[38]. The awareness that these compounds compromised the initial objectives of protecting humans, animals, plants, and microbes from damage and lowering the incidence of plant and animal pests resulted from their widespread usage. Consequently, produced items and food. The majority, however, believed that it was crucial to understand how toxic they are to plants. Use of systemic insecticides may result in sharp growth decreases in petunias and other non-target plants. Pesticides have a wide range of effects on blooming. The compounds found in pesticides, herbicides, and certain systemic pesticides have therefore been proven to have the potential to obstruct plant growth and development[39].

The effectiveness of seed germination and the early stages of plant growth are severely hampered by the use of pesticides. The germination and growth of seedlings of the radicle and plumule of Cicer arietinum and Zea mays were hindered and promoted, respectively, by the pesticides used in the study (Captaf, Bavistin, Blitox, Sitara, and Domarck). The radicle and plumule's germination and development were most strongly accelerated by carbendazim in Zea mays and Cicer arietinum. Its use may have enhanced growth metrics because, among other things, it decreased or eliminated the pathogenic population. The observed acceleration of development might perhaps be explained by an increase in the synthesis of substances that aid in growth, such as cytokinin or gibberellin. By inducing the release of structural proteins and a reduction in the transportability of leaf cells, systemic pesticides have an osmotic shock effect on plants, delaying their growth[40].

Additionally, it's likely that the glucose concentration may decrease, much to how protein synthesis might be inhibited[41]. Early studies showed that the toxicant produced by pesticide spraying inhibited the utilization of alternative respiratory pathways and changed the activity of cytochrome oxidase[42]. Seed viability, germination, and early seedling development (radicle and plumule) were all substantially influenced by all dosages tested. With higher doses of these pesticides, it was shown that both the rate of germination and the rate of growth decreased. For instance, a 0.25% concentration of Blitox was associated with the fastest rate of growth, which was then followed by a 0.50% concentration and a 1% concentration. Some pesticides are slower to degrade at higher concentrations, and there are signs that these concentrations have a range of detrimental effects on plant growth[43].

Many studies have examined how pesticides prevent plant development, particularly seed germination, In a research the effects of four days of exposure to three insecticides and two herbicides on the germination of rice seedlings, seedlings treated with diazinon had the greatest germination rate (85%), while seeds treated with fipronil had the lowest (76%) when compared to the control group. When the herbicides atrazine and metolachlor were applied together, the germination rate of rice seedlings was greater (81%) than when atrazine was applied alone (72%)[44]. Few studies over the last few years have examined how pesticides impact the germination of various crops.) Another research reported adverse effects of alachlor and propachlor herbicides on Hordeum vulgare L. germination because of interference with related metabolic processes (Devlin and Cunningham 1970). The 2,000 mg L1 of fipronil significantly decreased rice germination after only four days[45]. Glyphosate significantly reduced germination of Avena fatua seed when applied to plants 5 and 10 days after anthesis (DAA), with the highest effective rate being 1.76 kg a.i ha1; however, when applied to plants 15 DAA, only the highest rate significantly affected the overall germination[46]. In the present research work, five different seeds of vegetable crops (radish, turnip, green beans, lady finger and brinjal) were evaluated for their germination with different concentrations of selected pesticides (Atrazine and Bifenthrin) available in Pakistan which are being extensively used in agriculture sector. The main objectives of the research work were as follows.

To assess the impact of Atrazine and Bifenthrin (pesticides) on the germination of vegetable seeds (radish, turnip, green beans, lady finger and brinjal).

To find out the concentration-dependent effect of Atrazine and Bifenthrin on seed germination of the tested vegetable crops.

Materials and Methods

Collection of seeds: The seeds of different vegetable such as *Solanum melongena* (brinjal), *Raphanus sativus* (radish), *Brassica rapa subsp. Rapa* (Turnip), *Abelmoschus esculentus* (okra) and *Phaseolus vulgaris* (green beans) obtained from a shop in Burewala, Pakistan. Seed were carefully collected with no apparent infection/damage.

Research design: The experiment was conducted in the laboratory of Department of Environmental Science at COMSATS University Islamabad-Vehari campus. In this experiment total120 plastic boxes were used in two units having 60 boxes in each unit. The seeds were treated with solutions of two types of pesticides; P1 (Atrazine) and P2 (Bifenthrin) concentrations including C0 (control), C1 (1 ppm), C2 (10 ppm), and C3 (25 ppm) with three replications using factorial design with 2-way interaction. All the treatment combinations of the experiment are mentioned into two tables for ease of understanding (Table 1 and 2).

Determination of germination: The growth of seeds was observed at various intervals for 10 days. A seed was said to have germinated when its radicle appeared.

Determination of roots and shoots length: Seedlings were divided into roots and shoots after 10 days of growth, and their length in centimeters was measured after 5 days.

Determination of fresh and dry weight of and shoots: Seedlings were weighed with an electronic balance and then air dried for two days to calculate the fresh and dry weight of root and shoot and after that, they were placed in paper bags and oven dried at 60°C for 4 hrs before being weighed for dry weight.

Statistical analysis: The outcomes were recorded and submitted to each treatment value, which was represented by the Standard Deviation (SD). In addition, Factorial design with 2-way interaction (Tukey test) and MS Excel 2016 was applied for statistical analysis of data.

RESULTS

In the present research work, seeds of five different vegetables including *Raphanus sativus* (radish), *Brassica rapa subsp. Rapa* (Turnip), *Phaseolus vulgaris* (green beans) *Abelmoschus esculentus* (okra) and *Solanum melongena* (brinjal) were evaluated for their germination with different concentrations of extensively used pesticides (Atrazine and Bifenthrin) in agriculture sector in Pakistan (Fig. 1).

Effect of atrazine on seed germination: The *Solanum melongena* (brinjal) and *Raphanus sativus* (radish) shown 100 percent growth and *Phaseolus vulgaris* (green beans) and *Abelmoschus esculentus* (okra) shown 90 and 85 percent and there is no growth of *Brassica rapa subsp. Rapa* (Turnip) (Fig. 2, Table 3).

Effect of atrazine on fresh and dry weight: The Effect of pesticide on fresh weight of seedling shows that Abelmoschus esculentus (okra) have highest fresh weight that is 2.50 g and *Solanum melongena* (brinjal) have lowest fresh weight that is 0.40 g (Fig. 3).

In dry weight the *Abelmoschus esculentus* (Okra) have highest weight that is 0.25 g and *Solanum melongena* (brinjal) have lowest dry weight that is 0.05 g as compared to other crops as shown in graph (Fig. 4).

Effect of Atrazine on length after 5 and 10 days: After 5 days the growth in root and shoot in crop seedlings was different. The lowest growth in length was observed in *Solanum melongena* (brinjal) that is 2 cm and *Phaseolus vulgaris* (green beans) have highest length that is 11 cm as shown in graph, *Abelmoschus esculentus* (okra) and Raphanus *sativus* (radish), have 5 cm and 4 cm dry weight (Fig. 5a)

Table 1: Effect of Atrazine on seed germination of vegetable crops

Vegetable crops	Common name	C_0 (control)	C_1 (1 ppm)	C_2 (10 ppm)	C_3 (25 ppm)
S_1 *Raphanus sativus*	Radish	S_1C_0	S_1C_1	S_1C_2	S_1C_3
S_2 *Brassica rapa*	Turnip	S_2C_0	S_2C_1	S_2C_2	S_2C_3
S_3 *Phaseolus vulgaris*	Green Beans	S_3C_0	S_3C_1	S_3C_2	S_3C_3
S_4 *Abelmoschus esculentus*	Okra	S_4C_0	S_4C_1	S_4C_2	S_4C_3
S_5 *Solanum melongena*	Brinjal	S_5C_0	S_5C_1	S_5C_2	S_4C_3

Table 2: Effect of Bifenthrin on seed germination of vegetable crops

Vegetable crops	Common name	C_0 (control)	C_1 (1 ppm)	C_2(10 ppm)	C_3 (25 ppm)
S_1 *Raphanus sativus*	Radish	S_1C_0	S_1C_1	S_1C_2	S_1C_3
S_2 *Brassica rapa*	Turnip	S_2C_0	S_2C_1	S_2C_2	S_2C_3
S_3 *Phaseolus vulgaris*	Green Beans	S_3C_0	S_3C_1	S_3C_2	S_3C_3
S_4 *Abelmoschus esculentus*	Okra	S_4C_0	S_4C_1	S_4C_2	S_4C_3
S_5 *Solanum melongena*	Brinjal	S_5C_0	S_5C_1	S_5C_2	S_4C_3

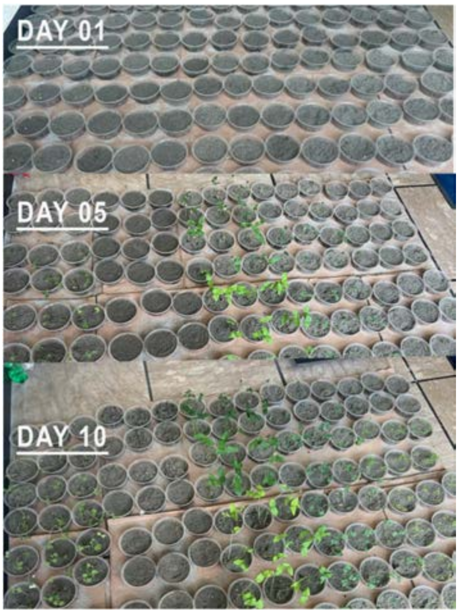

Fig. 1: Seed germination of selected vegetables with different concentrations of pesticides

Table 3: Analysis of variance for Dry weight, Fresh weight, Germination percentage, Length after 5 days and Length after 10 days for the effect of Atrazine

Parameters /source	DF	SS	MS	F	p-value
Dry weight (g)					
Replication	2	0.00297	0.00149		
Concentration	3	0.00482	0.00161	0.60	0.6212
Crop	4	0.50948	0.12737	47.25	0
Concentration*Crop	12	0.034339	0.00287	1.06	0.4162
Error	38	0.10244	0.0027		
Total	59	0.65411			
Grand Mean 0.1270 CV40.88					
Fresh weight (g)					
Replication	2	0.0216	0.0108		
Concentration	3	0.8099	0.270	1.52	0.2255
Crop	4	56.8137	14.2034	79.84	0
Concentration*Crop	12	0.868	0.0723	0.41	0.952
Error	38	6.7598	0.1779		
Total	9	65.2731			
Grand Mean 1.2213 CV 34.53					
Germination percentage					
Replication	2	40	20		
Concentration	3	12.6	42.2	0.55	0.6438
Crop	4	90026.7	22506.7	295.59	0
Concentration*Crop	12	373.3	31.1	0.41	0.9511
Error	38	2893.3	76.1		
Total	59	93460			
Grand Mean 77.000 CV 11.33					
Shoot length after 5 days					
Replication	2	3.206	1.603		
Concentration	3	2.939	0.979	0.59	0.6239
Crop	4	784.878	196.22	118.73	0
Concentration*Crop	12	29.414	2.541	1.48	1.734
Error	38	62.803	1.653		
Total	59	883.238			
Grand Mean 4.5204 CV 28.44					
Shoot length after 10 days					
Replication	2	1.26	0.632		
Concentration	3	6.63	2.209	1.26	0.3021
Crop	4	1326.64	331.66	189.02	0
Concentration*Crop	12	11.78	0.981	0.56	0.8602
Error	38	66.67	1.755		
Total	59	1412.98			
Grand Mean 6.6421 CV 19.94					

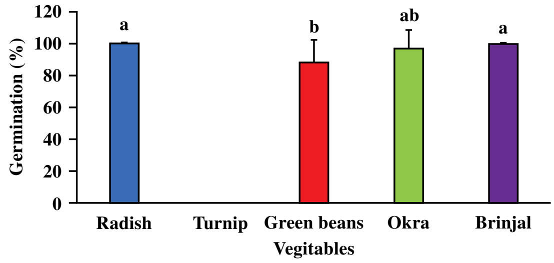

Fig. 2: Effect of Atrazine on germination of vegetable seedlings

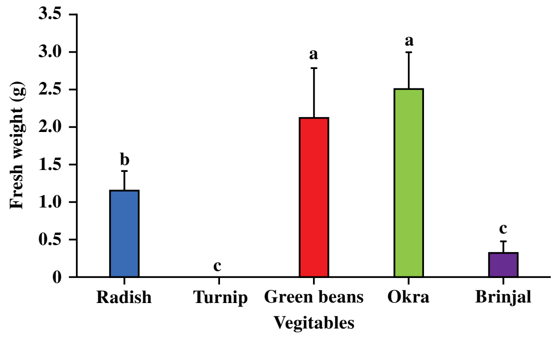

Fig. 3: Effect of Atrazine on fresh weight of vegetable seedlings

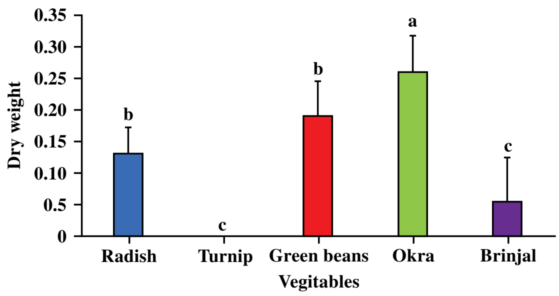

Fig. 4: Effect of Atrazine on dry weight of vegetable seedlings

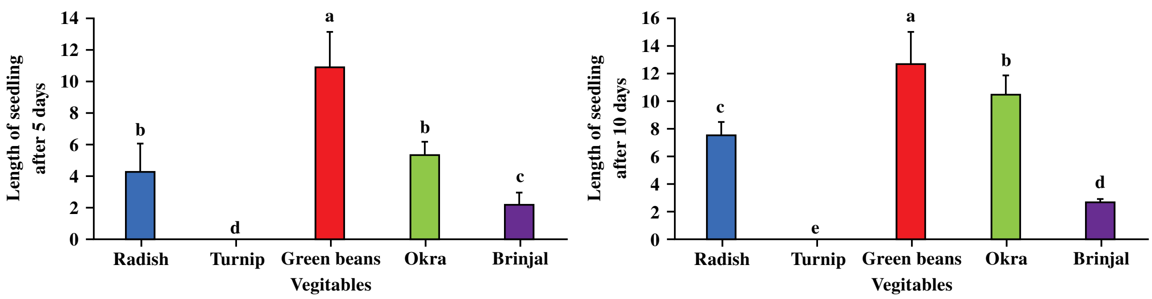

Fig. 5(a-b). Effect of Atrazine on length of vegetable seedlings (a) after 5 days and (b) 10 days

After 10 days the *Phaseolus vulgaris* (green beans) have highest length that is 13 cm and *Solanum melongena* (brinjal) have the lowest length that is 3 cm as shown in graph. *Abelmoschus esculentus* (okra) and *Raphanus sativus* (radish) have 10 and 7 cm length (Fig. 5b).

Effect of Bifenthrin on seed germination: The effect of Bifenthrin on seed germination is different in these crops at different concentrations, such as, *Solanum melongena* (brinjal) shown 100% germination in all concentrations, *Abelmoschus esculentus* (okra) have 100% germination in C1 and C3 and have less germination in C2, *Phaseolus vulgaris* (green beans) shown 100 percent germination only in C2 and other concentration have less germination rate, *Raphanus sativus* (radish), radish have 100% germination in C0 and C3 and other 2 concentration have less that 100% germination (Table 4 and Fig. 6).

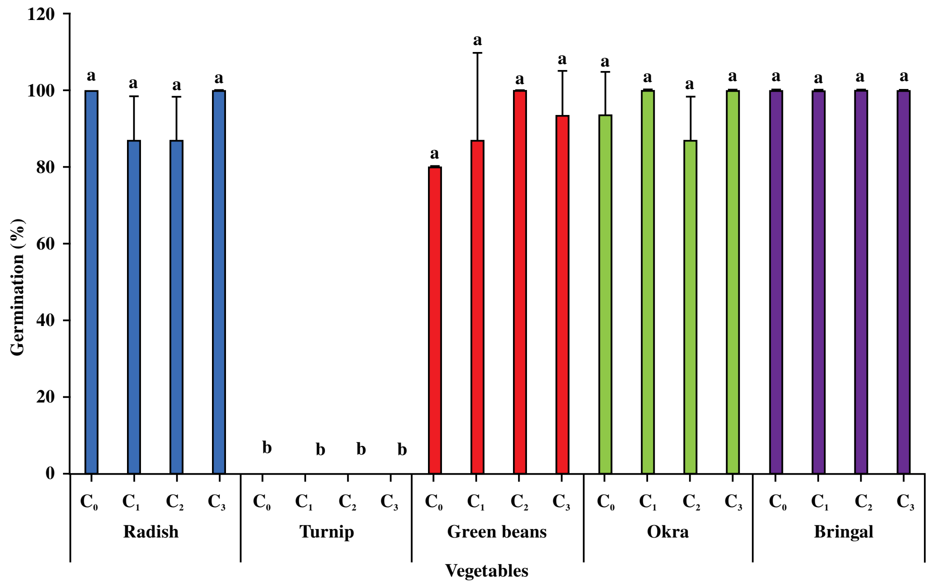

Fig. 6: Effect of Bifenthrin on germination of vegetable seedlings

Table 4: Analysis of variance for dry weight, fresh weight, germination, length after 5 days and length after 10 days for the effect of Bifenthrin

Parameters/source	DF	SS	MS	F	p-value
Dry weight (g)					
Replication	2	0.00956	0.00478		
Concentration	3	0.00612	0.00204	0.39	0.7642
Crop	4	0.60259	15065	28.46	0
Concentration*Crop	12	0.10547	0.00871	1.65	0.1196
Error	38	0.20112	0.00529		
Total	59	0.92395			
Grand Mean 0.1348 CV 53.95					
Fresh weight (g)					
Replication	2	1.2456	0.6228		
Concentration	3	5.1047	1.7016	6.32	0.0014
Crop	4	40	10.0321	37.24	0
Concentration*Crop	12	1285	0.7558	2.81	0.0077
Error	38	9.0693	0.2694		
Total	59	10.2356			
Grand Mean 1.0392 CV 49.94					
Germination percentage					
Replication	2	213.3	106.7		
Concentration	3	180	60	1.04	0.3848
Crop	4	86506.7	21626.7	375.83	0
Concentration*Crop	12	1386.7	114.6	2.01	0.0511
Error	38	2186.7	57.5		
Total	59	90473.3			
Grand Mean 75.667 CV 10.03					
Shoot length after 5 days					
Replication	2	8.345	4.1727		
Concentration	3	63.451	21.1504	8.12	0.0003
Crop	4	392.792	98.1981	37.7	0
Concentration*Crop	12	76.997	6.4164	2.46	0.0172
Error	38	98.967	2.6044		
Total	59	640.553			
Grand Mean 3.2804 CV 49.20					
Shoot length after 10 days					
Replication	2	13.66	6.828		
Concentration	3	149.56	49.855	14.47	0
Crop	4	907.64	226.909	67.09	0
Concentration*Crop	12	128.21	10.648	3.26	0.0034
Error	38	128.52	3.382		
Total	59	1327.58			
Grand Mean 5.4175 CV 33.95					

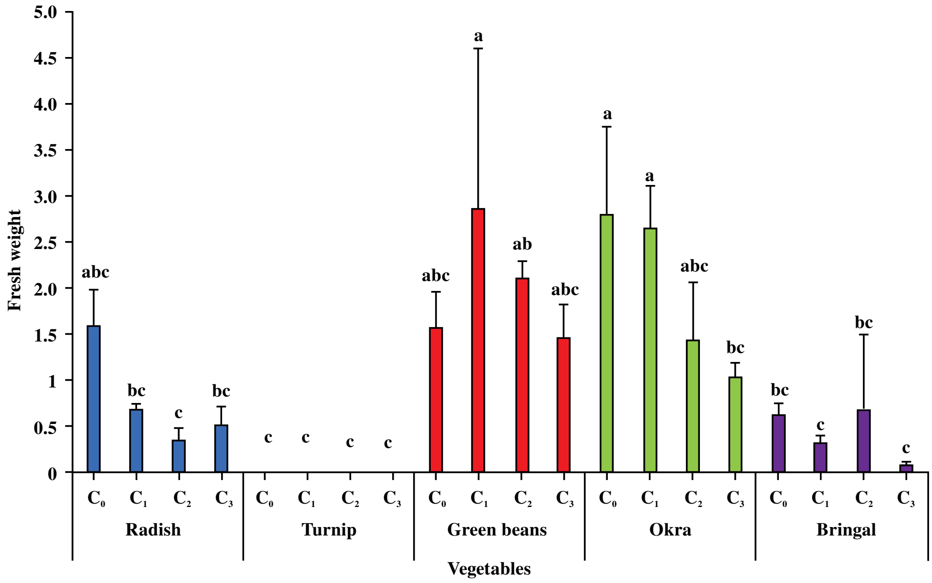

Fig. 7: Effect of Bifenthrin on fresh weight of vegetable seedlings

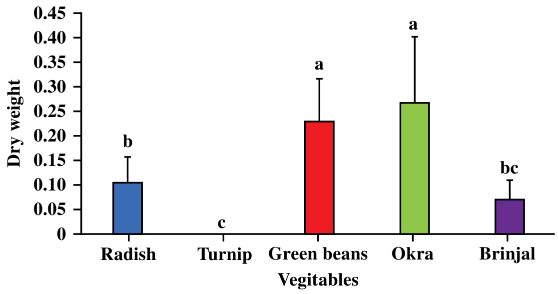

Fig. 8: Effect of Bifenthrin on dry weight of vegetable seedlings

Effect of bifenthrin on fresh and dry weight: The effect of Bifenthrin on fresh weight is different in each crops *Phaseolus vulgaris* (green beans) at C_1 concentration have highest fresh weight that is 2.60 g and lowest weight at C_3 shown in graph, In *Solanum melongena* (brinjal) the highest fresh weight is in C_2 that is 0.10 g and have lowest fresh weight in C_3, In *Abelmoschus esculentus* (okra) highest fresh weight shown in C_0 concentrations and other concentration have lowest weight, in *Raphanus sativus* (radish) the highest weight is in C_0 concentration that is 1.50 g and other concentrations have less weight (Fig. 7).

In dry weight, the highest weight is observed in *Abelmoschus esculentus* (okra) that is 0.25 g and lowest weight is observed in *Solanum melongena* (brinjal) that is 0.07 g and other crops such as *Phaseolus vulgaris* (green beans) and *Raphanus sativus* (radish) have 0.10 and 0.20 g weight respectively (Fig. 8).

Effect of Bifenthrin on length after 5 and 10 days: The result of both roots and shoots in different crop seedlings at various doses was different. After 5 days *Phaseolus vulgaris* (green beans) show highest length at different concentration and *Solanum melongena* (brinjal) shows lowest length at different concentrations, *Abelmoschus esculentus* (okra) have highest length in C_1 and *Raphanus sativus* (radish) have highest length at two concentrations that are C_0 and C_1 (Fig. 9).

After 10 days the, *Abelmoschus esculentus* (okra) have highest length at $C_1$and have maximum growth at other concentrations and *Solanum melongena* (brinjal) have the lowest length at each concentration, *Raphanus sativus* (radish) and *Phaseolus vulgaris* (green beans) have maximum growth in $C_0$and C_1 as shown in graph (Fig. 10).

DISCUSSION

Pesticides are contemporary techniques for eradicating diseases, weeds, and pests to increase crop output. Manufacturers of pesticides advise using insecticides at a particular dose. In developing countries like Pakistan, pesticide dealers frequently offer to farmers higher pesticide doses than those recommended by the manufacturer[28]. Usually, these bigger quantities will harm the crop. The

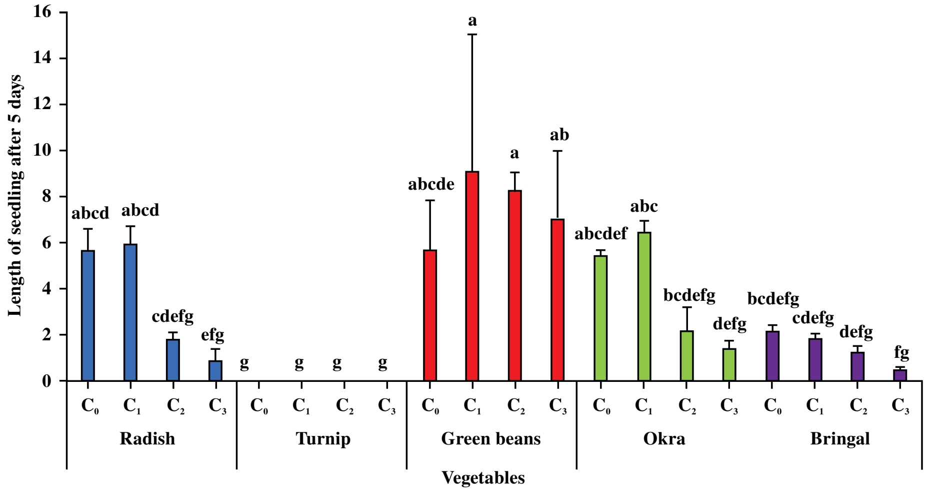

Fig. 9: Effect of Bifenthrin on length of vegetable seedlings after 5 days

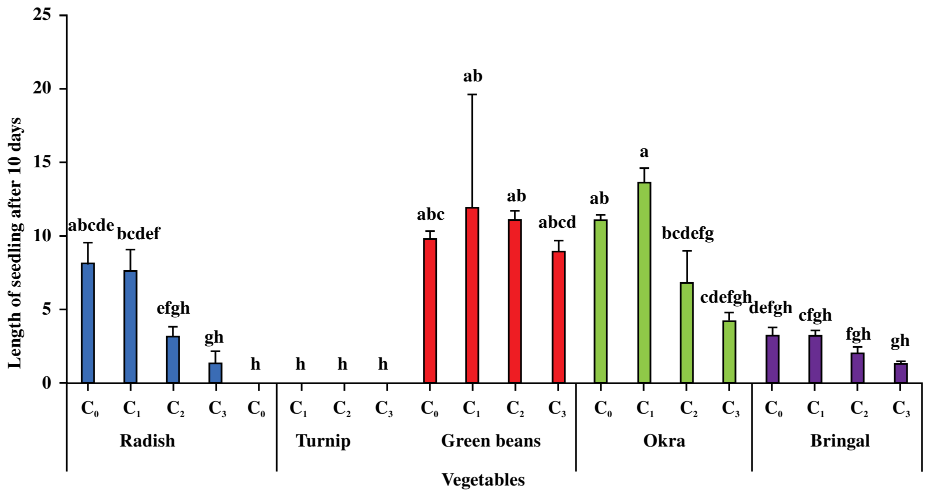

Fig. 10: Effect of Bifenthrin on length of vegetable seedlings after 10 days

current study was conducted to evaluate the impact of pesticides at varying concentrations on diverse crops as a consequence.

High dosages of insecticides kitazin and endosulfan reduced brinjal (*Solanum melongena* L.) germination was reported by Sammaiah et al[47]. Similarly, it is discovered that many pesticides impede germination of seed in various species of plant such as *Solanum melongena*, *Pisum sativum*, *Capsicum annuum*, *Zea mays*, *Typha latifolia*, *Solanum Lycopercun* and *Brassica nigra*[48-51]. In the current study, it was also discovered that in the early stages of exposure, germination was more vulnerable to pesticide stress than in the later stages. It shows that a pesticide may not completely inhibit germination at some dosages, but it may delay it. Bifenthrin, one of the pesticides looked at in this study, had the worst impact on the germination of brinjal and radish seeds, whereas Atrazine had the least impact.

Saeidi and Mirik[52] revealed that in flax seed, seed germination was not significantly reduced as it was treated with Carbendazim 0.15% and Captan 0.2% except for few seeds after long storage periods. However, our results show that greater doses of Atrazine and Bifenthrin (1, 10 and 25 ppm) increases the seed germination. Our experimental results fortify the authors' previous findings[25], who reported Fungicide concentrations at higher levels are harmful to plant growth parameters. Some concentrations have been found to be very phytotoxic to plants. Pesticides' effects on seed germination and plant growth ultimately have an impact on health and productivity of plant It reduces fertility of soil, which contributes in crop plant production losses in general. Our findings strongly suggest that using pesticides containing Bifenthrin at higher concentrations (25 ppm) was positively impact the seed germination and seedling growth.

When exposed to higher pesticide stress, fresh and dry weight of root and shoot decreased significantly. Pesticides such as triadimenol and triticonazole have previously been shown to reduce biomass production in wheat[53]. They came to the conclusion that pesticides have an impact on biomass through altering seedling development, shoot growth, and root axis formation. Pesticides have also been shown to have negative impacts on the production and physiology of various plants. Tobacco was severely harmed by abamectin and cartap at higher dosages[54] and picea sitchensis was adversely affected by dimethoate, malathion, and primicarb[55]. Several plant species, including soybean[5], maize[48], tomatoes[50], and chickpea[56], have seen slower overall plant development as a result of higher pesticide dosages. Our finding reported that Atrazine and Bifenthrin increase the fresh and dry weight in okra and green beans in all the concentrations, and decreased the weight of brinjal and Radish.

The increase in growth metrics could be due to its decreased application and its removal of pathogenic populations, among several considerations. An increase in growth stimulating substances such as cytokinin or gibberellin production may also result in growth stimulation. Earlier research showed that pesticide-derived toxins slowed protein and carbohydrate synthesis by altering cytochrome oxidase function and limiting alternate respiratory pathways[42]. It was discovered in the current experiment using plastic boxes that the fungicide utilised had both an inhibitory and a growth-promoting effect on the germination and growth of the green bean seeds and seedlings.

From the current study, it can be inferred that using pesticides in excess of the dosage advised can harm the growth of seeds. All of the studied pesticides had harmful effects on all of the vegetable seeds when administered at greater concentrations. According to the data, pesticides increased seed germination. However, all of the tested pesticides reduced the growth of various vegetable seeds when used at concentrations higher than those advised. However, when used at lower doses, the pesticides had some stimulatory effects on growth when compared to the control.

CONCLUSION

The present study demonstrated that pesticides, particularly Atrazine and Bifenthrin, exert variable effects on seed germination, seedling biomass, and growth parameters of different vegetable crops. Among the tested species, *Solanum melongena* (brinjal) and *Raphanus sativus* (radish) consistently showed 100% germination, while *Phaseolus vulgaris* (green beans) and *Abelmoschus esculentus* (okra) displayed slightly reduced germination rates, and *Brassica rapa subsp. rapa* (turnip) failed to germinate under all conditions. Fresh and dry weight analysis revealed that okra produced the highest biomass, whereas brinjal recorded the lowest. Growth measurements indicated that green beans attained the greatest shoot and root lengths, while brinjal remained the least responsive across all observation periods. Furthermore, the response to different concentrations of Bifenthrin was crop-specific: brinjal showed 100% germination at all concentrations, while germination in okra, radish, and green beans fluctuated depending on the pesticide dose. Similarly, fresh and dry weight patterns varied with concentration, with okra and green beans performing better at certain levels, while brinjal consistently showed the weakest growth. Overall, the findings highlight that pesticide exposure influences not only germination but also subsequent seedling vigor and growth, with significant inter-specific differences. These results emphasize the importance of optimizing pesticide use, as inappropriate concentrations may hinder the establishment and productivity of sensitive crops like turnip and brinjal, whereas others such as okra and green beans exhibit greater tolerance.

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