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Effects of Exhaust Pollutants and Garden Soil on Seed Germination and Seedling Growth of Maize *(Zea mays L.)* and Sunflower *(Helianthus annuus L.)*

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Authors' contributions

This work was carried out in collaboration among all authors. Author NZ performed the experimental work and statistical analyzed the data. Author MZI designed and supervised the study. Author MS managed the literature searches and wrote the first draft of the manuscript. Authors MK and ZRF critically reviewed the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Aim: This study was conducted to examine the effects of exhaust pollutants and garden soil extract on seed germination and seedling growth of some economically important crops, maize and sunflower.
Study Design: The *in-vitro* experimental design was completely randomized.
Place and Duration of Study: The experimental site was Department of Botany, University of Karachi, Pakistan and the experiment was lasted for 10 days in Ecology laboratory.
Methodology: The seeds of maize and sunflower were placed in front of the generator to exposed exhaust pollutants daily, 10 minutes, for 10 days. After the exposure of exhaust gas seeds were shifted into Petri dishes. The garden soil was obtained from mini garden of the Department of Botany, University of Karachi. The different concentrations of garden soil with distilled water were made and filtered. This filtered solution was assumed as the standard solution, which was 100%.

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From this standard solution, further dilution of 25%, 50% and 75% were made. Distilled water was used as a control for the experiment. Three best seedlings were selected from each Petri dish for the determination of mean values of seed germination (percentage), root, shoot and seedling length and seedling dry weight.

Results: This publication will help to understand the importance of exhaust pollutant impact and soil on crop growth and productivity. The soil quality influences plant growth and identifies the impact of exhaust emission on plant growth. The effects of exhaust pollutants of the generator and different concentration of garden soil on seed germination and seedling growth of two important crops *Zea mays* (L.) maize and sunflower *Helianthus annuus* (L.) were recorded. The treatment of different concentration of garden soil extract (0, 25, 50, 75, and 100%) affected seed germination percentage, root, shoot, and seedling length and seedling dry weight of both crop species. The soil extract at 25% significantly ($p<0.05$) affected the seed germination percentage of *H. annuus* as compared to control. The treatment of soil extract also decreased seedling growth performance of *Z. mays* and *H. annuus* as compared to control. A significant ($p<0.05$) decrease in seedling length of *Z. mays* becomes evident that exhaust treatment affected the seedling dry weight performance of maize as compared to control. Similarly, exposure of exhaust pollutant affected the seedling dry weight of *Z. mays* and *H. annuus* as compared to control treatment. The effects of garden soil extract on seed germination and seedling growth of *Z. mays* was found higher as compared *H. annuus*.

Conclusion: It was concluded that the treatment of exhaust emissions from a portable power generator fueled negatively affected the seed germination and seedling growth performance of maize and sunflower as compared to control treatment. A comparison between the seed germination percentage, seedling growth and biomass production performance of maize was found highly affected as compared to sunflower.

Keywords: Biomass; germination; growth; maize; petrol generator; seeds; sunflower.

1. INTRODUCTION

Pakistan is a developing country and its environment-related problems are increasing due to fast industrialization and unplanned urbanization. The economic and industrial activities are demanding an exponential increase in energy demands in all segments of societies. The shortage of electrical power throughout the country and the use of alternate energy resources has become an important issue since the last few years. The use of Generator is one of the rising demands of everyone to overcome the shortage of electricity and is widely used in industries, factories, hospitals, offices, petrol pumps and in homes. By the running of these generators or combustion process a large amount of oil, petrol and natural gas is burned which emit various pollutants in the air likewise, carbon dioxide, sulphur dioxide, oxides of nitrogen, formaldehyde, hydrocarbons of different molecular weight, ammonia, carbon monoxide etc. The direct contact of these pollutants creates adverse consequences on human health as well as on plants life. The ever increasing use of petroleum products and the burning of all fossil fuel can have a negative impact on earth biosphere. The clogging of stomatal pores and gas exchange ability of leaves are commonly reported in literature. In the last few years the growing scientific evidence has indicated that the air within homes and buildings could be more polluted than the outdoor air. The researchers have indicated that people spend approximately most of their time indoors thus for many people's health is at risk. Effects of sodium chloride on germination and seedling growth of Sunflower has been endorsed by Chowdhury et al. (2018).

Fumigation of increased concentration of hydrogen chloride gas during single 20-min exposure from 13 to 27 mg m^{-3} significantly increased the visible foliar injury of beans and radishes [1]. A significant increase in the dead leaf mass of *Lolium perenne* and *Phleum pretence* exposed to low levels of either NO_2 or NO was observed [2]. Dust scraped from an engine exhaust gas settled on leaf surface reduced photosynthesis and leaf diffusion resistance of roadside trees [3]. High values of metal accumulation in plants located near highways were also observed. Contamination by heavy metals decreased rapidly with increasing distance from the highway [4]. Fumigation of SO_2 on soil and plant growth resulted increase in contents of total sulphur, organic carbon and exchangeable aluminium (Al) and decrease in contents of nitrogen (N), phosphorous(P), and

Exchangeable potassium (K) and calcium (Ca), leading to reductions in length of root and shoot, number of leaves nodules and pods, phytomass accumulation and net primary productivity of Vicia faba plants [5]. Exhaust gases from gasoline combustion also impaired the photosynthetic apparatus under laboratory conditions [6]. Exposure of plants to mixtures of pollutants (sulphur dioxide, ozone, nitrogen oxide and hydrogen fluoride) generally found to increase the level of inhibitory responses such as physiological and growth parameters [7]. Previous research has shown that at high concentrations many of the pollutants present in exhaust gases could damage the plants [8-10]. Several other studies have also reported increased leaf senescence in response to air pollution. Saxe [11] demonstrated pre mature senescence for several species of polluted plants following exposure to high levels of NOx leading to changes in their physical properties and structure [12].

Currently, there is an intensive discussion about reducing global green houses gases. It is proposed that ethyl alcohol, and sugar cane as fuels could have a significant contribution in reducing CO_2 emission [13]. Gratani et al. [14] found that although the foliage of Quercus ilex trees had a reduced life span following exposure to high combustion emission in Rome, this was compensated by higher stomatal conductance, chlorophyll content and photosynthetic activity. Leaf surface characteristics were reported to be affected, having less chlorophyll content during combustion, while other pollutants, including sulphur dioxide and volatile organic compounds, are emitted together with carbonaceous particles from incompletely burned fuel droplets [15].

The petrol engine commonly available today generates electricity and is one of the contributors to environmental pollution problems. The combustion of fossil fuels is the main culprit in increasing the global carbon dioxide (CO_2) level resulting in a consequence of global warming [16]. The exhaust emitted by the petrol engines contains a large number of chemicals, gases and particulate matter, all of which can have significant toxic effects on biota of any region. Therefore, this study was carried out with the aim to find out the effects of exhaust pollutants emissions from a portable power petrol generator on seed germination and seedling growth of *Zea mays* (L.) maize and sunflower *Helianthus annuus* (L.).

2. MATERIALS AND METHODS

2.1 Species Description

2.1.1 Sunflower, *Helianthus annuus* (L.)

The seeds are the gift of the beautiful sunflower *Helianthus annuus* (L.) that has rays of petals emanating from its bright yellow seed studded in center. The flower produces grayish green or black seeds encased in teardrop shaped gray or black shells that often ties feature black and white stripes. Since these seeds have very high oil content, they are one of the main sources of polyunsaturated oil. Seeds are an excellent source of vitamin E and body's primary fat-soluble antioxidants.

2.2.2 Maize, *Zea mays* (L.)

Maize, *Zea mays* (L.) is commonly known as corn. Maize is a large grain plant domesticated by indigenous peoples in Mesoamerica in prehistoric times. The leafy stalk produces ears, which contain the grain. The seeds are called kernel and maize kernels are often used in cooking as a starch.

The seeds were purchased from the market.

Two plant species maize (*Zea mays L.*) and corn (*Helianthus annus* L.) were selected for the present experimental work. In order to analyze the effects of exhaust pollutants the generator used in experiment was petrol generator of rated power of 2.5 KW. The output of generator was AC single-phase 230 volts, whereas its speed was 3000 / 3600. The engine type was four stroke single cylinders with cooling system air dry. Frequency was 50 /60 and fuel tank was 10 liters. It runs on petrol and natural gas, whereas lubrication oil is also provided for better performance.

The seeds of sunflower {(*Helianthus annus* (L.)} and maize {Zea mays (L.)} were selected to analyse the effects of exhaust pollutants of generator and garden soil extract. The seeds were placed in front of generator to exposed exhaust pollutants daily 10 minutes for 10 days. After the exposure of exhaust gas seeds were shifted into Petri dishes. The Petri dishes and filter paper were sterilized in an autoclave to prevent any type of microbial contamination. Seeds were sterilized by 1.0 N sodium hypochlorite solution for one minute to prevent any fungal contamination and thereafter the

seeds were washed repeatedly with distilled water. The seeds were imbibed for half an hour to break the dormancy of seed and then transferred into medium size Petri dishes on filter papers (Whatman No. 42). Ten seeds were transferred in Petri dish at room temperature 30°C. The garden soil was obtained from mini garden of the Department of Botany, University of Karachi. Soil sample was passed through 2 mm sieve to remove gravels and other materials. The different concentrations of garden soil with distilled water were made and filtered. This filtered solution was assumed as the standard solution, which was 100%. From this standard solution, further dilution of 25%, 50% and 75% were made. Distilled water was used as a control for the experiment. Initially, seeds were treated with 5 ml of respective solution and later replaced with 2 ml of fresh solution on alternate days. All Petri dishes were kept in dark for seed germination and later shifted in light. Germination percentage was recorded daily and seedlings were removed from Petri dishes after 10 days of growth. Three best seedlings were selected from each Petri dish for the determination of mean values of seed germination (percentage), root, shoot and seedling length (cm) and seedling dry weight (g). The seedlings were dried in an oven at 80°C for 24 hours until the seedlings were completely oven dried. The experimental design was completely randomized and lasted for ten days.

2.2 Statistical Analysis

Statistical significance was carried out by Analysis of variance (ANOVA) and Duncan's Multiple Range Test (DMRT), according to the procedures of the Statistical Analysis System using personnel computer software packages SPSS version 14.0. Least significant differences selected at $P \leqslant 0.05$ were used for multiple means comparison tests. Determinations were means of triplicate analyses.

3. RESULTS

The effects of exhaust pollutant of generator and garden soil extract on seed germination, root, shoot, seedling length and seedling dry weight of *Zea mays* L. and *Helianthus annuus* L in different concentration of garden soil (0, 25, 50, 75 and 100%) were observed (Tables 1-2). The seedlings of *Z. mays* and *H. annuus* responded differently with the in different concentration of garden soil as compared to control (Table 1). The treatment of soil extract concentration at all level did not produce any significant ($p<0.05$) difference in seed germination and root length of *Z. mays* as compared to soil extract (Control). The soil extract treatment at 100% concentration increased the root length (9.90 cm) of *Z. mays* as compared to control (7.50 cm). The soil extract treatment at all level significantly decreased shoot length (6.53 cm), (7.06 cm), (8.40 cm), (8.30 cm) as compared to control (10.17 cm). The soil extract treatment at 25, 50 and 75% significantly $p<0.05$ decreased seedling length (17.03 cm), (14.40 cm) and (16.20 cm) as compared to control (17.66 cm). A slight increase in seedling length (18.20 cm) of Z. mays with the treatment of soil extract at 100% as compared to control (17.66 cm) was recorded.

The negative effects of exhaust pollutant emission were found responsible for the decrease in the seed germination percentage of *H. annuus* when treated with different concentration of garden soil extract as compared to control (Table 2). The treatment of 25% soil extract significantly $p<0.05$ affected seed germination percentage of *H. annuus* as compared to control. The seed germination percentage of *H. annuus* at 75 and 100% soil extract treatment responded similar rate of seed germination percentage as compared to control. The soil extract treatment at 75 and 100% concentration showed a gradual decrease in root length and shoot length of *H. annuus* as compared to control. The soil extract treatment at 25 and 50% concentration showed also a gradual decrease in seedling dry weight of *H. annuus* as compared to control. The treatment of 75 and 100% soil concentration showed further decrease in seedling dry weight performances of *H. annuus* as compared to control. The soil extract treatment at all treatments concentration showed more toxic effects on seedling growth performance of *H. annuus* than *Z. mays*.

4. DISCUSSION

Plants require an adequate supply of light, water and nutrient for normal growth. The disturbances in environmental and soil quality produce a negative impact on plant growth. The emissions from the petrol engine contribute to the problems of air, water, soil pollution, reduction in the visibility and effects on vegetation changes are common. In a number of comparative studies plants have been exposed to different types of engine petrol, diesel, oil, gas, gasoline, and all have found to be the same drastic damages to the plants. It has been reported earlier that direct

contact of plants with exhaust gases showed severe symptoms of damage as compared to plant at some distance [17]. In present studies, there was a significant ($p<0.05$) difference in seedling growth performances of *Z. mays* in all treatment of exhaust gas exposure as compared to control. Shoot length highly decreased on 25% soil extract treatment as compared to control observed. The growth of plants could be affected by several reasons and one of them is the presence of toxic pollutants derived from generator and absorbed by the treated seeds. The shoot length variation in replicates of spinach was due to equal distribution of environmental factors [18] and disturbances in physiological processes in plants [7]. Germination and seedling establishment are vulnerable stages in plant life cycle [19]. In another investigation, the responses of herbaceous plants to urban air pollution due to exhaust emission resulted in species-specific changes in growth and phenology, with a constant trend for accelerated senescence and delayed flowering [20]. In *Helianthus annuus* no significant ($p<0.05$) was observed in seedling growth performances as compared to control which might be due to its resistance to exhaust pollutants. The net productivity of *H. annuus* seedlings was decreased with the decreased in root length, shoot length and seedling length as compared to control. Many results related to air pollution confirm that exhaust pollutants contain many toxic gasses, which could lead to reductions growth parameters of plants. The reason of high percentage of reduction in seed germination percentage of *H. annuus* might be due to the introduction of exhaust pollutants released from petrol emission and become toxic to seed germination. The results were same like finding of [21-23] who reported toxic effects of automobile pollution exhaust emission on plants and seed germination behaviour of *Cassia siamea* and *Peltophorum ptercarpum.* The interest in diesel engine has increased today [24] but diesel exhaust is a major environmental pollutant [25]. The significant effects of generator (Exhaust) Fumes on the growth and height of *Lycopersicum esculentus* and on wild plants were also evaluated [26-27].

Table 1. Effects of different garden soils extract concentration on seed germination, root, shoot, seedling length and seedling dry weight of Maize (*Zea mays* L.)

Treatments garden soil extracts concentrations (%)	Seed germination (%)	Root length (cm)	Shoot length (cm)	Seedling length (cm)	Seedling dry weight (g)
Control (0)	100.00a±0.00	7.50a±0.28	10.17a±0.22	17.66ab±0.88	0.89a±0.05
25	100.00a±0.00	9.83a±0.44	6.53a±0.63	17.03ab±1.02	0.79a±0.06
50	100.00a±0.00	7.33a±0.60	7.06a±0.29	14.40a±0.66	0.70a±0.11
75	100.00a±0.00	7.80a±2.15	8.40a±0.30	16.20ab±1.48	0.69a±0.07
100	100.00a±0.00	9.90a±0.78	8.30a±0.02	18.20b±1.03	0.93a±0.03

Numbers followed by the same letter in the same column are not significantly different according to Duncan Multiple Range (DMRT) test. Mean ±Standard Error

Table 2. Effects of different garden soils extract concentration on seed germination, root, shoot, seedling length and seedling dry weight of sunflower (*Helianthus annuus* L.)

Treatments garden soil extracts concentrations (%)	Seed germination (%)	Root length (cm)	Shoot length (cm)	Seedling length (cm)	Seedling dry weight (g)
Control (0)	73.33b±6.66	2.20a±1.15	3.35a±0.44	6.03a±1.50	0.27a±0.05
25	16.66a±12.01	1.45a±0.74	1.66a±0.88	3.13a±1.57	0.13a±0.06
50	26.66a±13.33	2.23a±1.36	2.66a±1.36	4.90a±2.67	0.21a±0.11
75	6.66a±6.66	0.33a±0.30	1.06a±1.06	1.40a±1.40	0.07a±0.07
100	6.66a±6.66	0.26a±0.26	0.66a±0.66	0.93a±0.93	0.03a±0.03

Numbers followed by the same letter in the same column are not significantly different according to Duncan Multiple Range (DMRT) test. Mean ±Standard Error

5. CONCLUSION

It is concluded that plants are affected by exhaust emission and responded differently. The seeds of *Z. mays* and *H. annuus* subjected to exposure to petrol engine generator and treated with different concentration of garden soil extract responded differently to seed germination and seedling growth. The seedlings of both crops get some resistance to exhaust emission, mainly depend upon the exposure time and type of plant species. *H. annuus* showed better resistance to exhaust pollutant than *Z. mays*. The use of new technology for the improvement of use of petrol engine is required that can reduce the burden of environmental pollution effects. It is also suggested that the plantation of such types of species eventually results in significant emission reductions and lessen the burden of pollutants from the environment.

COMPETING INTERESTS

Authors have declared that no competing interests exist

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