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REVIEW ARTICLE

# Effect of Pesticide Residues on Agriculture Crops

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**Abstract**

This review provides a comprehensive and integrated image of the application of pesticides to This review provides a comprehensive and integrated image of the application of pesticides to plants and their impact on metabolism and development. Agrochemicals aimed at increasing crop yields and protecting crops from pests were introduced decades ago. New pesticides are commercialized and used to support crops every year causing numerous side effects and increased the investment cost for the protection of crop production. Free biological chemical farming is also gaining more support, but it is still insufficient to cope with massive food demand. Particularly in tropical regions and southern countries, the use of agrochemicals, including pesticides, remains a popular practice. DDT, HCH, and Lindane, which are inexpensive and persistent in the atmosphere, are no longer used in agriculture in developed countries, but they are still widely used in developing countries. As a result, food is contaminated by residual traces of these chemicals and dispersed into the atmosphere. The aim of this review was therefore to analyze the early application of the impact of pesticides from germination to planting growth, phycological and biological alterations in various enzymatic pathways, and non-enzymatic antioxidants, which ultimately affect yield and result in residues in plants, vegetables, and fruits.

**Keywords**

Pesticide residues
Agricultural
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## Introduction

The word pesticide (is to control pests) covers a wide range of chemicals, including insecticides, fungicides, herbicides, plant growth regulators, etc. It has been used since farmers started technical approaches for sustainable agricultural practices, and the Sumerians rubbed their bodies with sulphur compounds (foul-smelling) as a pesticide for controlling insects, ticks, and mites in 2500 BC, which was the first deliberate use of it in ancient times. Now it is commercially used synthetic pesticides in agricultural production; e.g., such as organophosphate (OP) insecticides, carbamates, and pyrethroids, as well as herbicides and fungicides. Due to the abrupt rise in the human population in the last three decades, pesticides along with agrochemicals, in general, have become a crucial part of global agricultural systems to improve crop quality and yields, and food production. Besides the population, internally and externally displacement refugees, adverse climate change on agriculture land and water crises in Asia are continuously threatening food security and on the other, they have been directly pressing the utilization of pesticides for food production.

So, a wide range of it has been used worldwide to control pests and weeds without considering other

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aspects of it on water quality, biodiversity, and human health (Tang et al., 2021). Hence, human is exposed to such chemicals indirectly and directly such as it is apparent that the risk of pesticide exposure is highest among farm employees. The use of less managed and monitored pesticides and accidental exposure can cause the greatest potential of toxicological pollution to the whole population. It leads to premature death and was blamed for a predictable 9 million premature deaths, 16% of all world's deaths. Approximately, it is third times higher than AIDS, tuberculosis, and malaria (Landrigan et al., 2018; Tang et al., 2021). Spray drift, off-target accumulation, photodegradation, run-off, etc are thought to account for just 0.1 % of the total amount of pesticides applied for weed and pest control that eventually enters the sites of activity (Jayaraj et al., 2016). The detail of its health hazards of it provides in the Global database of pesticide applications which showed about 92 active ingredients (pesticides) are used and responsible for environmental pollution (Tang et al., 2021).

Accidental pesticide exposure can occur during processing, formulation, and application, as well as from environmental residues left behind after application. Many negative consequences have resulted from the unselective and unfit use of chemical pesticides in agriculture, including environmental degradation, ecological imbalance, pesticide residues in grain, fruit, vegetables, fodder, soil, and water, insect resurgence, and so on (Parween et al., 2016). Currently, pollution by the usage of synthetic chemicals is more common worldwide. It might be short-term exposures (STE) of them that have high acute toxicity but are easily metabolized and eliminated the greatest risk. Long-term exposure (LTE), even at relatively low doses, poses the greatest risk with a penchant to accumulate in the body. However, some of them which are eliminated readily but with LTE can cause severe chronic biological pollution even with low-dose exposures. Additionally, other ingredients of these synthetic chemicals such as solvents, emulsifiers also have a side effect on the ecosystem (Parween et al., 2016).

Simultaneously, we've learned in recent decades that agrochemical toxins have penetrated the environment, so contaminated terrestrial ecosystems and poisoning of human foods (Carvalho, 2017). Also, it repeatedly threatened aquatic life and the food web. However, the choice of possible directions for improved food production must be generated by wise and science-based decision-making processes. So, research is important for finding alternative pathways of refined food production and safety to protect the environment. This review aims to identify several aspects of the selective impact of pesticides on plants, with a focus on germination, growth, and development, alteration of biochemical pathways and certain antioxidant enzymes, pesticide yield and residue in crops, as well as to assess the dose range from which benefits in terms of crop quality and yield could be derived.

**Role of Fertilizers and Pesticides:** Agricultural production has increased significantly by using fertilizer and pesticides to cope with the world population. Firstly, organic fertilizers were used in the late $19^{th}$ century, but mineral phosphate fertilizers were started using at the start of the $20^{th}$ century and continue up to now (Enríquez-Hidalgo et al., 2015). The green revolution is also due to the major contribution of phosphate fertilizers (Carvalho, 2006) along with pesticides. Human population growth and global phosphate production for fertilizer use have been closely and positively related over the last century (Roser and Ortiz-Ospina, 2017). Due to the significant importance of pesticides, their products are going to increase at an annual rate of about 11% per year (Kudsk et al., 2018). The main pesticides producing per year are organochlorine, organophosphate, carbamate, pyrethroids, and growth regulators, as well as bio-pesticides. Market values of pesticides have fluctuated since the last decade, the range of market value is herbicides > insecticides > fungicides. Pesticide use has not been uniforming across the world due to the cost of chemicals (most of which are patented), as well as the cost of specific pests in each climate/geographic region. Although herbicide usage in agriculture and urban areas has increased dramatically in North America and Western Europe in recent decades, herbicide use in Asia has remained low to very high in comparison to insecticide use (Carvalho, 2006).

**Effect of Pesticide on Growth and Metabolism of Crops:** The biological effects of pesticides are not clear or well understood on their target organism, even it is not clear, has it more advantages and disadvantages? A variety of mechanisms of pesticides has been reported; interference of biological processes such as photosynthesis, mitosis, cell division, enzymatic activity, root and leaf formation; intrusion with the synthesis of pigment, protein or DNA, obliteration of proper working in cell membranes process, promote irregular cell's growth. Sometimes it supports the biological process in seeds, vegetables, fruits, and various non-target species as early as germination (Takeda et al., 2003).

**Germination:** The adverse effects of pesticides on germination have been reported by many researchers. Pendimethalin controls seed germination up to 95%, i.e., the percentage of *Zea mays L* seed germination decreased drastically in the treated sets with increasing pendimethalin concentration (Rajashekar and Murthy, 2012). Similarly, about a 69% decline in germination was found at a 10.0 ppm pendimethalin concentration.

**Table 1: Negative effect of pesticides on seed germination**

| Pesticides | Negative effect on | Crops | References |
|---|---|---|---|
| Pendimethalin | Seed germination up to 95%, | Maize (cv. Nac-6002) | (Rajashekar and Murthy, 2012) |
| Fipronil | Seed germination up to 76% | Rice seedlings | (Moore and Kröger, 2010) |
| Diazinon | Seed germination up to 85% | Rice seedlings | (Moore and Kröger, 2010) |
| Atrazine+ Metalachlor | Seed germination up to 81% | Rice seedlings | (Moore and Kröger, 2010) |
| Atrazine | Seed germination up to 72% | Rice seedlings | (Moore and Kröger, 2010) |
| Alachlor | Seed germination | *Hordeum vulgare L* | (DEVLIN and CUNNINGHAM, 1970) |
| Propachlor | Seed germination | *Hordeum vulgare L* | (DEVLIN and CUNNINGHAM, 1970) |
| Pendimethalin | Seed germination | *Vigna radiata L* | (Nehru et al., 1999) |
| Trifluralin | Seed germination | *Zea Mays L* | (Nehru et al., 1999) |
| 2, 4-D, glyphosate | Seed germination | *Oryza sativa L* | (Hirase and Molin, 2002) |
| Bromacil | Seed germination | *Oryza sativa L* | (Hirase and Molin, 2002) |
| Chlorsulfuron | Seed germination | | (Tanveer *et al*., 2009) |
| Glyphosate | Seed germination | | (Tanveer *et al*., 2009) |
| Tribenuron-methyl | Seed germination | *Galium spurium L* | (Andersson, 1994) |
| Bentazone | Seed germination | *Xanthium strumarium L* | (Zhang and Cavers, 1994) |

It is predicted might be due to the herbicide's negative outcome on the deprivation and mobilization of seed reserves. Recently investigated the effects of insecticides (fipronil, diazinon) and herbicides (atrazine/metolachlor) in synergistic and mono effect on rice crop in a four-day exposure. Fipronil lower seed germination (76%) among the insecticides tested, compared to control (80%), whereas diazinon, like other insecticides, had a higher germination rate (85%) even when compared to control. In rice seedlings, the herbicide atrazine/metolachlor combination has a higher germination rate (81%) than the single herbicide atrazine (72%) (Moore and Kröger, 2010). Similarly, the negative effect of pesticides on seed germination is given in Table 1.

**Growth and Development of Crop:** Crop development fluctuates with the time and season and is influenced by exogenic and endogenic factors, such as genetic, nutritional, environmental, and hormonal factors (Jan et al., 2012b). Treatment with imidacloprid appeared to stimulate rather than inhibit development where there were significant differences. The researcher has applied various concentrations of it and found that range 500-1000 mg AI/L was very effective and above 2000 mg AI/L was not effective in plant growth and development. Imidacloprid has been tested as a seed treatment on wheat and barley crops and early growth of crops. Similar results were found in many crops by the seed treatment with imidacloprid (Stevens et al., 2008). No significant difference was reported in the shoot and root systems of the treated and controlled plants. Dimethoate was found very adverse to root and shoot length growth of crops (Mishra et al., 2008). Similarly, monocrotophos rimsulfuron, imazethapyr, alachlor, fusillade, atrazine, and fluometuron reduced complete or partial growth at different concentrations (Saraf and Sood, 2002). Many other studies show that since these herbicide classes have been added, the growth of several plant species has been reported (Hassan and Alla, 2005). Herbicide disturbances in certain processes, such as those associated with nitrogen metabolism and photosynthesis, can cause a reduction in plant development (Nadasy et al., 2000).

**Biochemical and physiological effects:** Plant pesticide accumulation has been shown in previous studies to hinder plant growth and cause metabolic disorders. Chlorotoluron, terbacil, metribuzin, and antrakol disrupted the higher photosynthetic electron transport chain of fruit plants and in *Nicotiana tabacum L* respectively. Propanil, a highly selective post-emergence herbicide, is widely used to combat grass weeds in a variety of crops. The fungicide captan caused a decrease in the content of chlorophyll a, b, total chlorophyll, and carotenoid in pepper leaves, but the recommended dose caused an increase in the content of chlorophyll a and carotenoid as compared to higher dosages (Tort and Turkyilmaz, 2003). However, recommended captan dose of application is 2.5 g/L, which increased the number of carotenoids and internal leaf (Tort and Turkyilmaz, 2003). Furthermore, the reduced source of photosynthate to the roots may have resulted in a decline in functional symbiosis due to the toxic activity of atrazine and metribuzin, as well as the straight effects of these herbicides on *Brady rhizobium* growth in vitro (Alonge, 2000).

The study has reported that the nitrogen and protein content of grain was not significantly affected by pesticides (Khan et al., 2009). However, nitrogen uptake showed considerable variance. Pyrifos was found to be effective in controlling pod borer damage, this study also discovered that it was harmful to chickpea Rhizobia in the crop rhizosphere, reducing its survival significantly. As a result, the crop sprayed by pyrifos for pod borer control augmented grain yield with decreased nitrogen-fixing capacity by suppressing the rhizobium bacterial consortia population in the rhizosphere and spraying before pod formation is extremely injurious, resulting in decreased natural nodulation in the crop (Khan et al., 2009). A similar result was found in another study by applying paraquat to crop, which is resulted in decrease nodulation. The main decrease in nodule is due to rhizobium bacterial reduction by paraquat (Musarrat and Haseeb, 2000). Other than nitrogen content, chlorophyll content is also reduced by herbicides, it is due to chlorophyll degradation and activation of the oxidation mechanism by pesticide's toxicity (Kaushik, 2006).

Dimethoate was harmed by a concentration-dependent inhibition of photosynthetic oxygen yield and $CO_2$ fixation, which could be explained by dimethoate's direct effect on various photosynthetic electron transport chain sites (Mishra et al., 2008). In the same study, photosystem II and whole electron transport chain behaviors in chloroplasts were found to decrease at all dimethoate concentrations (Mishra et al., 2008; Nehru et al., 1999). It is most likely due to damage to the evolving oxygen complex, as evidenced by the complete recovery of PSII activity in the presence of artificial electron donors. Furthermore, excess dimethoate was used to disrupt the ability to transfer electrons at the PSII reaction center (P680) and the plastoquinone site (PSII reduction site) (100 and 200 ppm).

In an experimental study, triadimefon therapy in *C. Roseus* has increased the protein, amino acid, proline, and glycine betaine content in a different part of plants i.e., (leaves, stem, and root). Glycine betaine accumulates as a result of oxidative stress caused by fungicide use; it aids in the stimulation of tolerance mechanisms. Other studies have shown that protein content was increased by the treatment with pesticides such as, when *Echinochloa farmentacea* and *Brassica carinata* was treated with paclobutrazole and uniconazole, respectively, have high in protein content than controlled plants. By accumulating some particular metabolites such as amino acids, plants react to a range of stresses. It can give plants an extra layer of protection against abiotic stress-induced radical oxygen damage (Gopi et al., 2007).

**Antioxidative defense system:** External environmental stresses on a plant can cause a variety of physiological responses and oxidative damage in plants. Contaminants in the atmosphere can induce an intracellular overproduction of reactive oxygen (ROS) molecules, which can kill plant cells. The destruction of membrane lipids is evidence that the reaction of reactive oxygen molecules with macromolecules, especially lipoprotein, causes oxidative damage extra quickly (Jan et al., 2012a). Triazoles are a class of compounds that have fungicidal and plant growth-regulating properties. In comparison to control therapy, triazole treatment prevented electrolyte leakage and lipid peroxidation in carrot plants (Gopi et al., 2007). Catalase peroxidase, glutathione reductase, ascorbate peroxidase, and superoxide dismutase are activated to scavenge free radicals and peroxides to protect the seedling from the harmful effects of these stresses. Mefenacet herbicide treatment of rice seedling displayed increased superoxide dismutase and catalase-peroxidase behaviors (Prasad et al., 2005). The fungicides azoxystrobin and epoxiconazole significantly boost the activity of superoxide dismutase and catalase-peroxidase. Increased membrane permeability and MDA content, as well as a decrease in unsaturated fatty acid content, have all been linked to paraquat use, suggesting improved lipid peroxidation reactions. Superoxide dismutase cause overrun of $H_2O_2$ to eradicate the harmfulness of $O_2$. Ascorbate peroxidase is a cellular $H_2O_2$ reclamation enzyme that works via the ascorbate-glutathione scavenging cycle (Wu and von Tiedemann, 2002). In $H_2O_2$ scavenging process, it is the rate-limiting enzyme reported that glutathione-related, despite its increased activity, was not significantly associated with PQ-induced damage and played a limited role in protecting against photo-oxidative stress. The application of paraquat in the experiment is anticipated to primarily affect the PS1 region in the thylakoid membrane to interfere with antioxidant expression.

The paraquat effect will spread to other isoforms as the physiological damage spreads to other plant's parts. In addition to the high leaf wax content, increased ascorbate peroxidase and as a behavior in the youngest leaves most likely resulted in younger leaves having a higher tolerance to paraquat than older leaves (Yoon et al., 2011). The reduced absorption of paraquat would result in less herbicide damage to young plants due to the high wax content and increased detoxification of herbicide molecules entering the leaf cells. Paraquat resistance has been linked to superoxide ion scavenging ability and SOD activity in some plants. Superoxide dismutase behavior was higher in squash than beans in the oldest leaf, which was more susceptible to paraquat. This implies that superoxide dismutase isn't essential for paraquat reclamation and to protect the plant from oxidative stress in squash. Increased superoxide dismutase, catalase-peroxidase, and glutathione-related behaviors have been linked to natural resistance to paraquat in perennial ryegrass by other researchers. The various toxic sources of oxygen are neutralized by regular, enhanced enzyme activities, resulting in a reduction in lipid peroxidative reactions. Antioxidant enzymes such as catalase-peroxidase and peroxidase were determined in response to glyphosate treatment. In this treatment, both catalase-peroxidase and peroxidase increased herbicide tolerance in maize plants and tobacco (Basantani et al., 2011).

**Yield:** The yield of pod and seed are losing by pod borers and pod-sucking bugs. Although researchers focused on the seed yield losses, and have a very weak focus on pod loss by pests that use pods as a feed. These pests damage the pod and ultimately increase the loss of seeds that will be produced in a pod or sometimes produce with low quality and quantity in pod damage. As a result of the pesticides used, pod borers had a good protective cover against pod infestation, allowing for higher seed yields such as the most pods per plant, the number of seeds per plant, and the weight of dry seeds, in this study. Chlorpyrifos applied on the foliar region increased the number of pods per plant and also enhance the attributing characteristics of yield in mungbean seedlings. Improvement in stem strength and height, the number of leaves per plant, and nutrient uptake will be resulted in increased photosynthate translocation, resulting in more pods per plant e.g., rice and soybean seed yield has been increased by using chlorpyrifos (Chibu et al., 2002). The crops such as rice, maize, bean (AbdEl-Rehim et al., 2010), tomatoes (Glover-Amengor and Tetteh, 2008) have increased the yields by using pesticides in different experiments.

**Residues in vegetables and fruits:** The residue levels of vegetable and fruits has been increased due to use of pesticides unwisely and inequality on cereal and fruits crops. These residues also have another serious concern and side effect on public health, it may increase your body fat when consumed over a long time. A very limited data from food monitoring authority on residue analyses are available accurately to provide a true picture of residue’s side effect on public health and international trade (Sanborn et al., 2004). However, there is no standard for residue contents based on the same pesticides because it varies worldwide widely for the same pesticide on the same commodity, and difficult to set Maximum Residue Limits (Zikankuba et al., 2019).

**Conclusion and Perspective:** Pesticides are a viable choice for pest control, their indiscriminate application puts both targeted and non-target crops at risk. As a result, pesticide side effects must be interpreted in the context of their utilization after understanding the biological and agricultural processes to control pests. Studies should include the impact and persistence of pesticides on crops, as well as their effects on rhizobium, and other microflora that are associated with nitrogen fixation and metabolism. Alternative healthy methods, such as the creation of comparatively less expensive bio-pesticides, should be encouraged. Pesticide residues in food grains must be dissipated using more reliable methods, which must be produced and checked. Furthermore, studies should focus on identifying cell defenses and cell kinases that are triggered in response to pesticide toxicity.

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