Bulletin of Pure and Applied Sciences.
Vol.39 B (Botany), No.2.
July-December 2020: P.88-93
Original Research Article

Print version ISSN 0970 4612
Online version ISSN 2320 3196
DOI: 10.5958/2320-3196.2020.00014.2
Available online at www.bpasjournals.com

Effect of Soil Condition on Pesticide Behavior in Crop Field

Dr. Kumari Bindu*

Author's Affiliation
Dept of Botany, J.P University, Chapra, Bihar 841301, India

***Corresponding Author:**
Dr. Kumari Bindu
Dept of Botany, J.P University, Chapra, Bihar 841301, India

E-mail:
drkumaribindu@gmail.com

Received on 25.06.2020
Accepted on 16.10.2020

Keywords:
Persistence,
Pesticides,
Phytotoxicity ,
Adsorption,
Yield

Abstract
The persistence of pesticides in soil is a summation of all the reactions, movements, and degradations affecting these chemicals. Marked differences in persistence are the rule. For example, organophosphate insecticides may last only a few days in soil; the most widely used herbicide, 2,4-D, persists in soil for only two to four weeks; chlorinated hydrocarbons may persist from three to fifteen years or longer. The persistence time of hundreds of other pesticides, are between the extremes cited. The majority of pesticides degrade rapidly enough to prevent buildup in soil. Those that do not do so have potential for environmental damage. In the article authors have studied and discussed the pesticide persistence being directly affected by physical characteristics of soil.

INTRODUCTION

Soil Temperature

Increase in temperature has a beneficial effect on the absorption of phenoxy pesticide due to disorganization of the lipid materials on the cuticle and consequent increased membrane permeability. Similar beneficial effect is also obtained at high humidity which helps in the opening of stomata.

Soil pH

Soil pH affects the detoxification of pesticide by affecting the ionic or molecular character of the chemical, the ionic character and the cation exchange capacity of soil colloids, and the inherent capacity of soil microorganisms to react with the pesticide. The term soil pH refers to the pH of the soil solution, the water, and other elements that exist in a free state around soil particles. Basically, the pH number is related to the number of hydrogen (H^+) ions in the soil water solution; the more the hydrogen ions, the more acidic the solution becomes. As hydrogen ions decrease, hodroxyl (OH^-) ions increase, making the solution more basic. A pH value of 7 has equal number of hydrogen and hodroxyl ions and it is considered neutral.

Many pesticide are ionic which enables them, when in soil solution, to give off or attract hydrogen ions depending on the pH of the soil solution. For example, 2,4-D, MCPA, etc. which are acidic in character, can release hydrogen ions in a neutral or basic solution, while other pesticide which are chemically basic in nature can accept hydrogen ions in an acidic solution. Another group of pesticide is nonionic in character, and they do not react with water and do not carry an electrical charge. These include metolachlor, etc. Even though they are not ionic, many of them are polar and can be affected by soil pH, but the effect is generally smaller than with the ionic pesticide.

Differences in the pH of the soil affect its ability to absorb and retain the pesticide molecules. Harris and Warren (1964) found that soil pH influenced pesticide adsorption and that different pesticide responded differently to changes in soil pH. They also observed that as pH was lowered more hydrogen ions were associated with pesticide molecules to give them more cationic characteristics which would lead to more adsorption. Soil pH enhanced adsorption through its effect on the number of soil anion exchange sites and sites for polyvalent cation bridging and hydrogen bonding.

Soil pH also influences the phytotoxicity of pesticide by affecting their adsorption by soil and availability for plant uptakes. Grover, (1968) and Corbin *et al*., (1971) who found an increase in phytotoxicity as the soil pH increased and reached a maximum of 6.5 for the weak aromatic acids like 2,4-D and for the weak bases. They also found an increase in phytotoxicity as soil pH decreased and reached a maximum of 4.3. They observed that soil pH levels between 4.3 and 4.5 had no effect on the phytotoxicity of the weak nonionic pesticide. A change in one pH unit decreased the phytotoxicity of 2,4-D, by a factor of two to four depending on the herbicide and the pH values considered.

In a study Best *et al.* (1975) found that, liming an acid silt loam soil from pH 5.5 to 7.5 increased the phytotoxicity of atrazine and Harrison *et al.,* (1976) reported that phytotoxicity of atrazine was pH-dependent. Best and Weber (1974) found more rapid hydrolysis of atrazine to hydroxyatra- zine in soil at pH 5.5 than at pH 7.5.

Soil Moisture

The moisture content of soil system has considerable effect on both the degree of adsorption and the phytotoxicity of pesticide present in the aqueous phase. When a pesticide is applied to the soil it is partitioned into adsorption and solution phases.

Green and Obien (1969) found that the effect of a change in soil water content on pesticide concentration in solution was dependent on the magnitude of adsorption. Their results suggested that pesticide phytotoxicity should increase with increasing soil water content under most circumstances. Baumann and Merkle (1979) found a positive correlation between pesticide phytotoxicity and soil moisture.

Most of the pesticides have lower phytotoxicity at lower soil moisture contents. Bailey and White (1964) attributed this to the degree of competition of the organic compound for the adsorption sites at different moisture levels. Hance (1981, personal communication) observed that competition is important only when not enough water molecules are present to cover all colloidal surfaces. If there is enough water in the system for the plants to take it up, all surfaces will be covered with water, and so the competition phenomenon will not be observed.

Adams *et al.,* (1970) and Rust *et al.,* (1972) reported that the major determinant expressing atrazine injury to oats and soybeans was rainfall occurring during the seedling establishment period. They found that for each inch of rainfall above the minimum level where no injury occurred yields were reduced by 17% for a constant amount of *herbicide* or the amount of atrazine required to reduce yields by a constant amount decreased by 17%.

MATERIALS AND METHODS

Methods

The experiment entitled "Study of dimensions of soil pollution by pesticides in crop field of Saran (Chapra), Bihar" was conducted at Chapra during the Kharif Season 2012-2013 using the Parmal variety of rice. Crop was sown on August, 2012. The experiment was laid out in a RCBD design with four replications. In each replication, there were six treatments each with size of 5m x 1.8m. Row to row distance was kept at 30 cm. All the pesticides applied as post emergence as detailed in Table 1.

Table1: Treatments used in the experiment

Herbicides common names	Rate (kg/hectare)
2,4-D	0.02
Isoproturon	1.00
Metolachlor	0.75
MCPA	0.45
Bromaxaynil	0.04

To spray the pesticides successfully all the precautionary measures were adopted so as to avoid any misuse of the pesticides.

Soil Sampling

In each sampling, 20 g of soil was removed from each collection bag. About 5 g of this soil was placed in the oven at 105º C for 24 hours to determine the soil moisture content. The remaining soil was put in a flat-bottomed Flask to which 100 ml of methanol was added, and the mixture was shaken for one hour. The mixture was transferred to a Buchner flask and was filtered under partial suction. The collected organic phase was evaporated in a rotary evaporator for about 15 minutes, and the dried residues were dissolved in 10 ml of hexane. The extracts were stored in 15 ml glass vials in the refrigerator. Samples from the plough layer (upper 15-cm zone) of the different experimental fields were used for assessment of soil bioactivity. A minimum of 5 bags per plot were collected, pooled and mixed thoroughly before use. Sieved soil (5 mm mesh) samples, from experimental and control plots, were adjusted to about 55% maximum water holding capacity and kept, till use in a dessicator in a temperature regulated chamber at 24 °C. Soil samples were not stored more than two weeks.

RESULTS

Table 2: Moisture content of soil (Relateive Humidity)

Sl. No	Treatments	During crop season	After harvest
T_0	Control (Hand weeded)	80-85	30-40
T_1	2,4-D	78-88	25-35
T_2	Isoproturon	82-90	28-40
T_3	Metolachlor	80-90	26-40
T_4	MCPA	82-90	22-34
T_5	Bromoxynil	81-86	24-36

Moisture content of soil measured as relative humidity for different periodic observations during crop-season remained in between 78-90 in all treated crop-fields and control. Rice crop-soil remained as submerged in water for a longer period of cultivation, thus moisture content remained maximum as compared to other crops. The relative humidity of experimental crop-field's soil after harvest of crop remained in between 22-40. Thus it was clear that sufficient water availability in rice-crop field provided suitable medium for dissolution, percolation and absorption of used pesticides.

Table 3: pH of soil

Sl. No	Treatments	pH of soil		
		15 days	30 days	45 days
T_0	Control (Hand weeded)	5.5	5.8	6.0
T_1	2,4-D	6.0	6.5	6.5
T_2	Isoproturon	5.6	6.1	6.2
T_3	Metolachlor	5.8	6.2	6.4
T_4	MCPA	5.8	6.4	6.6
T_5	Bromoxynil	5.5	6.0	6.5

pH of the experimental crop fields were measured at different intervals as after 15 days, 30 days and 45 days after transplantation of crop. Overall pH for all experimental crop field's soil remained in between 5.5 and 6.6. But in all experimental crop fields an increasing trend of pH value were noticed by increasing days after transplant. This might be due to increase in organic content of the soil progressively.

Table 4: Temperature of soil

Sl. No	Treatments	Temp. of soil (At maturity of Crop)
T_0	Control	19°C
T_1	2,4-D	20°C
T_2	Isoproturon	19°C
T_3	Metolachlor	22°C
T_4	MCPA	21°C
T_5	Bromoxynil	21°C

Temperatures of the experimental crop field soil were measured for each treatments and control at the maturity of the crop and it remained in between 19-22°C. But during entire crop-season the temperature of soil remained lower.

DISCUSSION

Physical Characteristics of Soil (Moisture Content, pH and Temperature of Soil)
Persistence is a measure of the adaptive potential of pesticide and enables it to remain present in any environment. In an agricultural situation, the cropping system with its associated habitat management practices, determines the persistence of applied pesticides.

The important climatic factors of the environment that affect persistence of pesticide were as follows:-

- Light intensity, quality, and duration were important in influencing the growth, reproduction, and distribution of weeds and also to persistence of pesticides. Our experimental fields got good light intensity and duration.
- Temperature of atmosphere and soil affects the distribution of weeds and also persistence of pesticides. Soil temperature affects seed germination and dormancy which is a major survival mechanism of weeds. Temperature of soil at the time of maturity of crop was found as 20 °C during our environmental study.
- Rainfall and water have a significant effect on weed persistence and from those of aquatic environments. The pattern of rain is a determining factor in utilization of water supply by the plant, since water shortages at critical stages of growth was often responsible for reproduction and survival of weeds in experimental rice crop fields.
- Average relative humidity of soil ranged between 80 to 90 percent during crop season and between 22 to 40 after harvest of crop during experimental period.
- Soil factors which influence pesticide persistence are soil water aeration, temperature & pH. pH of the soil of our experimental fields ranged between 5.5 and 6.6.

Humidity has considerable influence on the development of cuticle, transpiration, and water stress. Relative humidity is more important than absolute humidity. Aqueous solutions enter the hydrated cuticle more easily. At high relative humidity, water content of the leaf is high and this facilitates free movement of the pesticide in the apoplast and the symplast. High turgor pressure in the protoplasm at high humidity leads to more active protoplasmic streaming and more rapid translocation in the pholem sieve tubes. This explains the rapid absorption and translocation of foliage-applied pesticides under high humidity conditions. Throughout our experimental period the crop field soil remained as highly humid.

An increase in temperature enhances absorption and translocation. Pallas (1960) found that at the temperatures 20°C, 25°C, and 35°C, less 2,4- D and benzoic acid was absorbed and translocated at lower humidities (34 to 48%) than at higher humidities. The increased absorption and translocation at higher humidity was correlated with the degree of stomatal opening. Such an increase in absorption and translocation at higher humidity is due to increased phloem transport. McWhorter and Wills (1978) reported that at a constant level of 40 to 100% relative humidity, an increase in air temperature from 22°C to 32°C resulted in a two- or three-fold increase in absorption and a four- to-eightfold increase in translocation of mefluidide in soybeans. Similarly, at a constant temperature of either 22°C or 32°C an increase in relative humidity from 40% to 100% resulted in less than two-fold increase in absorption and translocation of mefluidide.

The volatilization of a pesticide from soil or foliar surfaces depends mainly on the vapour pressure of the compound, its concentration, its adsorption to soil, and its solubility in water. It is also affected by air temperature, wind velocity above the soil surface, relative humidity, soil temperature, and soil moisture. Drift during spraying also provides an opportunity for volatilization. It is also influenced by the chemical nature of the compound. Some pesticides are metabolized or degraded relatively rapidly to more polar products which may be strongly absorbed to soil. Volatility can be a factor in reducing the effectiveness of a pesticide. In such cases, incorporation in soil or improved formulation reduces the loss by volatilization. Codistillation with water is sometimes explained to cause substantial loss of some pesticide from soil surfaces. Codistillation with water involves physical or chemical reaction between water and the chemical, with the product being more volatile than the parent chemical itself. However, codistillation is generally referred to as the creation by water of an interface at which the chemical is concentrated and/or at which the chemical is held with reduced energy. If the net result of the presence of water increases partition into the air phase it is commonly said that the volatility of the chemical has been enhanced by codistillation with water.

CONCLUSION

The various environmental factors that affect plant growth and hence pesticide activity and selectivity are temperature, rainfall (water), humidity, light, and wind. They largely influence absorption and translocation of pesticide by the plant. The environment before, during, and after the pesticide application, has considerable effect on the growth and development of the plant. This eventually affects the absorption and translocation of pesticide. It is difficult to isolate the effect of one environmental factor from the other.

REFERENCES

1. Adams R.S. Jr., Baker D.G. and Nelson S.E. (1970). Atrazine herbicides interactions in Soybeans, *Meeting of Weed Sci. Soc.Amer*, *Abst. No.-38.*
2. Bailey G.W. and White, J.L. (1964). Review of adsorption and desorption of organic pesticides by soil colloids with implications concerning pesticides bioactivity, *J. Agr. Food Chem., 12, 324-332.*
3. Baumann P.A. and M.G. Merkle, (1979). The effects of soil moisture on the phytotoxicity of diuron, fluridone and triffuralin, *Proc. Meeting Sou. Weed Sci. Soc.,* USA, P.-315
4. Best J.A. and J.B. Weber, 1974, Disappearance of S-triazines as affected by soil pH using a balance-sheet approach, *Weed Sci., 22, 364-373.*
5. Best, J. A., Weber, J. B. and Monaco, T. J. (1975). Influence of Soil pH on s-Triazine Availability to Plants. *Weed Science, 23*(5), 378-382. Retrieved December 7, 2020, from http://www.jstor.org/stable/4042341
6. Corbin, F.T., Upchurch R.P. and Selmen, F.L. (1971). Influence of pH on the phytotoxicity of herbicides in soil, *Weed Sci., 19(3), 233-239.*
7. Green R.E. and Obien, S.R. (1969). Herbicides equilibrium in relation to soil water content, *Weed Sci., 18, 514-519*
8. Grover, R. (1968). Influence of soil properties on the phytotoxicity of 4-amino-3,5,6-trichloro picolinic acid, *Weed Res., 8: 226-232*
9. Hance R.J. (1967). The speed of attainment of sorption equilibria in some systems involving herbicides, *Weed Res., 7, 29-33*

10. Harris, C.I. and G.F. Warren, (1964). Adsorption and desorption of herbicides by soil, *Weeds;* 12: 120-126.
11. Harrison G.W., Weber J.B. and Baird J.W. (1976). Herbicides phytotoxicity as affected by selected properties of North Carolina Soils, *Weed Sci., 24, 120-126*
12. McWhorter, C.G. and Wills, G.D (1978). Factors affecting the translocation of C-mefluidide in soybeans (*Glycine max*) and common cocklebur (*Xantbium pensylvanicum*).*Weed Sci., 26, (5), 434-440.*
13. Pallas, J. E. (1960). Effects of temperature and humidity on foliar absorption and translocation of 2,4-dichlorophenoxy- acetic acid and benzoic acid. *Plant Physiol Sep*., *35(5), 575–580.*
14. Rust R.H., Adams R.S. Jr. and Martin W.P. (1972). Developing a soil quality index, *In : Indicators of environmental quality, Plenum Press, New York*, *243-247*