Effects of Pesticides on Nitrogen Fixation

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ABSTRACT

EFFECT of various classes of pesticides on symbiotic and non-symbiotic nitrogen fixation has been discussed. The information available indicates that these chemicals used at recommended levels may not affect nitrogen fixation but repeated application can lead to the build up of chlorinated hydrocarbons to be toxic to the nitrogen fixing bacteria. Few studies also indicate beneficial effect of pesticides on nodulation and yield of legumes.

INTRODUCTION

Modern agriculture owes a great deal to agricultural chemicals, which are playing a key role in improving both production and protection potentials of feed, food and fibre. In the present system higher amounts of both plant production and protection chemicals are also applied than before. Consequently sizable amounts of pesticides reach soil directly and indirectly through above ground plant protection measures. Concern has been sometimes expressed about the side effects of these chemicals on useful but sensitive biological processes like nitrification and nitrogen fixation. Effect of various classes of pesticides on nitrification has been reviewed elsewhere (Sahrawat, 1974). In the present article the effect of various classes of pesticides on nitrogen fixation both symbiotic as well as non-symbiotic will be discussed and an attempt will be made to draw conclusions on the basis of the literature available It is made clear at the outset that the literature on the subject is very sparse. The effect of various classes of pesticides will be discussed under insecticides, herbicides and fungicides.

1. INSECTICIDES

Insecticides belonging to chlorinated hydrocarbons and organo-phosphate groups have been studied for their effect on nitrogen fixing bacteria both under isolated conditions as well as along with the host plant. In some cases the effect has been studied on the uptake of nitrogen and yields of the host plants From one of the earlier studies, Fults and Payne (1947) reported that the chlorinated insecticides DDT and colorado 9 used at field rates had no inhibitory effect on symbitoic nitrogen fixation. Since then there have been conflicting reports on the effects of insecticides on rhizobia and nodulation of legume crops. While some reports indicate no adverse effect on nodulation, yield and nitrogen content of legumes inoculated with specific rhizobia (Magu **et al.**; 1972, Pareek and Gaur, 1970; Selim **et al.**, 1970 and Simkover and Shenefelt 1951), there have been contrary reports reduction in the number and weight of nodules due to application of insecticides (Braithwaite **et al.**, 1958; Misra and Gaur. 1972.)

Gawaad **et al.** (1972) studied the effect of several soil insecticides on broad beans and Egyptian clover in laboratory and field experiments. In laboratory experiments broad beans and clover were grown for 30 days in soil treated with 0. 5, 10, 20, 30, 40, and 50 ppm thimet, lindane, temik, DDT or heptachlor and in a field experiment clover was grown for 60 days in soil treated with 0 and 12 kg/ha thimet and temik or with 0 and 21.4 kg/ha lindane. It was found that lindane, heptachlor and DDT significantly reduced nodule numbers on beans and clover roots The number of nodules on bean roots was reduced by temik at 30—40 ppm and on clover roots by 50 ppm temik. Thimet at 10—40 and 20—50 ppm increased nodule numbers on bean and clover roots respectively. Thimet, lindane and temik had no significant effects on the number of clover nodules in the field.

In pot experiments soil application of Dipterex and endrin stimulated the formation of nodules and increased the dry weight and total nitrogen content of broad beans and lentils (Taha **et al.**, 1972).

Soil treated with 1, 5 and 10 ppm of lindane was used for studying the effect of the insecticide on soybean. It was found that the increased levels of lindane application enhanced the number and size of nodules, dry matter production, yield of pods and nitrogen uptake in soybean plants. BHC helped symbiosis between the plant and Rhizobium (Balasubramanian. et al:. 1974).

Kulkarni et al., (1974) studied the effect of carbofuran, thimet, dasanite (fensulfothion) and heptachlor at recommended rates on groundnuts and found that thimet gave the greatest decrease in number of nodules per plant, followed by heptachlor and

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fensulfothion; nodules of treated plants were larger and heavier. Yields of pods, plant dry weight and nodule leghaemoglobin content were not significantly affected by these chemicals.

2. *HERBICIDES*

One of the process likely to be affected by the application of herbicides is legume nodulation (Alexander, 1961). Rankov et al,. (1966) reported that at normal field rates2. 4-bis (isopropylamino) 6-(methylthio) S-triazine (prometryne) caused an increase in the number of nodules on bean (Phaseolus) roots in field experiments while Avrov (1966)and Szabo (1964) observed that it inhibited both the number and size of nodules on peas (Pisum) . Avrov (1966) in an extensive study with different classes of herbicides found that recommended rates of many of the S-triazines, substituted phenols , chlorophenoxies and urea derivatives were not toxic to the pea-nodule bacteria in sterile soil suspensions. In field experiments, where simazine (2 chloro - 4, 6-bis (ethylamino) — S-triazine) was applied to maize (Zea mays L) annually for 3 years at the rate of 3 kg/ha. decreased growth and reduced nodulation was observed on peas planted in the same field in the 4th year, 2-chloro-4-ethyl amino) -6-(isopropyl amino) S (triazine) (atrazine) was found to have even greater residual effect. But a stimulatory effect was observed with simazine on the lupine nodule bacteria On a cultivated soil without naturally occuring **R. lupini** but inoculated with a commercial inoculum, it was found that recommended doses of simazine increased plant weight (Avrov, 1966).

Fults and Payne (1947) found that 2,4-D at field rates did not have any inhibitory effect on symbiotic nitrogen fixing bacteria. But Skrdleta **et al.** (1964) found that 2 4-D (2,4-dichlorophenoxy acetic acid) and MCPA (2 methyl 4-chlorophenoxyacetic acid) inhibited **Rhizobium** species Weaker effects were obseved with 3-amino — 1,2,4 triazole (amitrole) and and isopropyl-N (3-chlorophenyl) carbamate (CIPC). Vintikova **et al.** (1965) obtained similar results and concluded that the bacterial sensitivity was a property of the microbial strain and was independent of the plant species.

Garcia and Jordan (1967) have reported that dalapon (2,2-dichloropionic acid) had no effect on nodule number or weight in birdsfoot trefoil (**Lotus corniculatus**). 2,4-DB (2, 4 dichlorophenoxy butyric acid) reduced both factors, however and also adversely affected the N-fixing capacity of root nodules.

Dunigan **et al.** (1972) reported that none of the three rates of the seven herbicides had a detrimental effect on nodulation of the soybeans. High rates of chloramben, linuron. nitralin and prometryne demonstrated adverse effects. High rates of trifluralin, GS 16068 had an adverse effect on nodulation. Haucke-Pacewiczowa (1971) from pot experiment studies reported that with peas and serradella, the herbicides, Afalon, Aretit, Chwastox and Embutox usually had a negative effect on the yields and nitrogen fixation of plants Further a soil simazine content as low as 0.1 ppm greatly reduced yields and nodulation of pea. On the other hand in culture, a concentration of 0.0008 per cent simazine had not inhibitory effect on any strain of **Rhizobium phaseoli** but 6, 8 and 12 strains were inhibited at concentration of 0.0016, 0.0024 and 0.0048 per cent respectively (Makawi **et al** 1971).

Interesting but conflicting results have been reported on the effect of herbicide 2,4-DB alone or in combination with dalapon on nodulation of legumes. Though application of 2.4-DB alone or in combination with dalapon on **Lotus corniculatus** L (Garcia and Jordan, 1967) and dalapon on alfalfa (Lakshmi Kumari and Subba Rao, 1973) reduced nodulation; no such effect was observed by Kunelius (1974) on alfalfa.

Counts of **Azotobacter chroococcum** made 72 hours after incubation in both cultures, containing 2,4 5-T indicated that growth was almost completely inhibited at 1000 ppm and significantly reduced at 200 and 600 ppm. Although control population had stabilised by 72 hours, the population of treated cultures continued to increase upto 168 hours, suggesting adaptation of the bacteria. **Rhizobium leguminosarum** tested in a similar manner was even more sensitive to 2, 4, 5-T and was completely inhibited at 1000 ppm (Foldery **et al.,** 1972).

Sharma and Saxena (1974) studied the effect of 2 4-D on multiplication of soil microorganisms after inoculating with azotobacter and found that the increasing amounts of the herbicide in soil upto 4.5 ppm level increased the counts of azotobacter upto 2nd. 14th and 32nd day after treatment. However, application of 2, 4-D beyond 4.5 ppm (recommended field dose) showed toxicity to azotobacter.

3. *FUNGICIDES*

The importance of nitrogen fixing bacteria in increasing legume yields and nitrogen economy is very well known. Sometimes the seeds are inoculated with specific **Rhizobium** to increase yield and at the same time equally important is the seed disinfection with fungicides to guard it against seed and soil borne pathogens. So it is imperative to study the effect of seed disinfectants on the efficacy of **Rhizobia.** Few studies have been made to study the effect of fungicides on nitrogen fixation.

Application of ceresan in pot experiments caused a decrease in the number of nodules both in broad beans and lentils. This effect was more pronounced in sterilized soils (Taha **et al.**, 1972). On the other hand, Kecskes and Vincent (1973) reported that under field experiments on red basaltic soils seed treatment with ceresan and Spergon both seriously interfered with nodulation and decreased yield, thiram stimulated both nodulation and yield of **Vicia sativa**.

Sardeshpande **et al.** (1974) reported that captan, ceresan and Brassicol did not adversely affect nodulation in groundnut plants inoculated with **Rhizobium** and were safe at recommended rates. Further, seed treatment with captan first, followed by **Rhizobium** was beneficial in improving the nodulation status and crop growth in groundnuts. Curley and Burton (1974) studied the compatibility of **Rhizobium japonicum** with chemical seed protectants and observed that at two weeks' age, tap root nodulation of soybean was directly related to number of rhizobia. In these tests. captan and parachloronitrobenzene (PCNB) reduced viable rhizobia and tap root nodulation. Thiram. on the other hand had no adverse effect on viable rhizobia or tap root nodulation.

CONCLUSIONS

With the limited information available on the effect of pesticides on nitrogen fixation, following conclusions can be drawn from the above discussions :

1. Recommended doses of pesticides in general do not have any harmful effect on nitrogen fixation. Few studies do show their stimulatory effect on nodulation and yields of legumes.
2. Chlorinated hydrocarbons may have adverse effect on nitrogen fixation due to their persistent nature which results in build up of their residues when used occasionally to be toxic to nitrogen fixing bacteria.
3. Herbicides have a direct effect on the plant system due to their phytotoxic nature and these may also affect nitrogen fixation by affecting the host plant.
4. Though the little available literature indicates that fungicidal seed treatment is safe as far as nitrogen fixation by **Rhizobium** in symbiosis with legumes is concerned. More studies on the effect of seed protectants on nitrogen fixation and nodulation are necessary.
5. Occasional survey of system for the bacterial activity responsible for nitrogen fixation will prove very useful for trouble shooting.

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