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(RESEARCH ARTICLE)

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Phytotoxicity of common pesticides to physiological and biochemical makeup of *Triticumaestivum*var. Lok-1

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Abstract

Field experiments were conducted to evaluate the impact of five different pesticides (Triazocel, Superkiller-25, Vitavax power, Cut-out and VAAR) belonging to different chemical groups on the germination, plant growth, carbohydrate, protein and chlorophyll content and the yield of wheat crop. VAAR was found the most toxic pesticide resulting in significant decrease in all the parameters of the crop and above 3 ppm concentration brought forth aborted wheat seeds in all the replicates. Vitavax power was the least toxic pesticide and resulted in stimulation of most of the studied parameters. All the pesticides except Vitavax power were toxic and showed increasing toxicity with increasing concentration. Repetitive and intense use of these pesticides by mostly the illiterate farmers of the state of Madhya Pradesh particularly towards the maturity of the crop has resulted in pesticide residues in the soil. The results recommend limited use of triazocel, superkiller-25 and cut-out for wheat pest control and strictly prohibiting VAAR application. The residues of VAAR need to be checked prior to sowing wheat in the fields for assured returns.

Keywords: Vitavax power; Wheat; Toxicity; Germination; Chlorophyll

1. Introduction

Pesticide toxicity to humans and animals is a prime focus of research today however the insalubrities to actual recipient plants have decreased concern. With the advent of more sophisticated target oriented chemicals, pesticide toxicity increased many fold and the stress to crop plants resulted in diminishing yields [1, 2].

Pesticide toxicity is already proved in animals and human beings and increasing literature is also accumulating regarding their toxicity to plants [3, 4]. Since plants in cultivation form the actual target interface of interaction between the active ingredient and the pest, the resultant impact on the plant need to be flagged. Prior studies in the field indicate decrease in earlier growth and lower yields at maturity [5, 6, 7], germination suppression, morphological deformities and sterlity [8, 9], cereals with lesser number of tillers, unfolded leaves and spikelets and shorter stem [10] in addition to mutagenic and carcinogenic effects[11, 12] and skewed biochemical parameters [13, 14, 15] in plants. Pesticides are known to persist in soil for varied time periods depending upon the soil type, pH, temperature, the weather of the area and the soil biota in addition to the physical and chemical properties of the pesticide. A report [16] confirmed the presence of organophosphates, organochlorines, pyrethroids and carbamate pesticides in different crops, vegetables, soil and water samples in the state of Haryana and since the agriculture is more aggressive in the state of Madhya Pradesh, the pesticide residues are expected to be more.The present study is a preliminary approach to evaluate the impact of pesticides belonging to organophosphates, pyrethroids, phenoxy acids, imidazolinines and thiocarbamate chemical groups on the physiological and biochemical makeup of wheat.

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2. Material and methods

The experiments were conducted in the wheat growing seasons (25 Oct. to 04 Mar.) from 2014-15 in the field of Department of Botany, Govt. Madhav Science College, Ujjain (23.1607 ^{0}N, 75.8063 ^{0}E). The soil (Black cotton – pH 7.2, electric conductivity 0.360, nitrogen 213 kg/h, phosphorus 19.49 kg/h and potassium 400 kg/h) was sun dried and sieved through a 2mm mesh and measured quantity (7Kg dry weight) was filled in earthen pots of 10litre capacity each. Wheat seeds of variety Lok-1 were disinfected with sodium hypochlorite and five pesticides, Triazocel (Triazophos 40% EC), Superkiller-25 (Cypermethrin 25% EC), Vitavax power (Carboxin37.5%+Thiram 37.5% WS), Cutout (2,4-dichlorophenoxy acetic acid 48% EC) and VAAR (Imazethapyr 10% SL), belonging to five different chemical groups were applied according to their recommended applying procedure (triazocel, superkiller, 2,4-D and imazethapyr-foliar spray, Vitavax power-seed dresser. The pesticides were selected for being in wide use in the study area. Five concentrations of each pesticide ranging from 0.1 ppm to 6 ppm were applied. These concentrations are the least that can remain as residues and impact the growth of the plants. Randomization of the Experiment was ensured through completely randomized block design. Three replicates for each of the fifteen treatments and a control were run simultaneously. Twenty seeds were sown per pot and regular watering was ensured to keep the soil moist. Seedlings were divided into two groups and readings were recorded from a selected group after every 15 days for initial 60days and then a final reading was taken on ripening. The other group of seedlings was used for assessing yields only. The temperature during the growing season ranged from 13.5 °C to 33 °C ± 1 °C with a humidity of 39.214 % ± 12.01 to 68.35% ± 4.66. The physical parameters evaluated were germination and plant length; biochemical parameters included chlorophyll content, carbohydrate content and protein content. In addition, the impact on yield of the crop due to the different pesticides was also assessed.

3. Results and discussion

Germinating seeds act as a model system for assessing the toxicological potential of pesticides [18]. In the present study the percentage increase or decrease in germination of wheat seeds was evaluated for different concentrations of varied pesticides belonging to different chemical groups. All the pesticides were found to decrease the germination percentage in wheat seeds relative to control except Vitavax power which gave positive results. All the used concentrations proved toxic to germination. With the increase in concentration of the pesticides, the germination percentage decreased. In case of Vitavax power, however, with the increase in concentration, the germination percentage of wheat increased except at its 6ppm concentration. Among the group of used pesticides, VAAR was the most toxic pesticide to germination of wheat and Vitavax power the least toxic pesticide. Similar results for organophosphates, pyrethroids and 2,4-D were obtained by some studies [19, 20] and[21].

Pesticides are also known to delay the germination. Reports suggest asynchronous and delayed germination of seeds on treatment with xenobiotics [21, 22]. The present study confirmed the impediment of germination upon application of different pesticides. The germination percentage decreased by varying amounts in different pesticides. Wheat germination was retarded the most by VAAR (20%) and 2,4-D (20%). The decreasing order of toxicity of other used pesticides is superkiller (8%), triazocel (7%) and Vitavax power (4%).

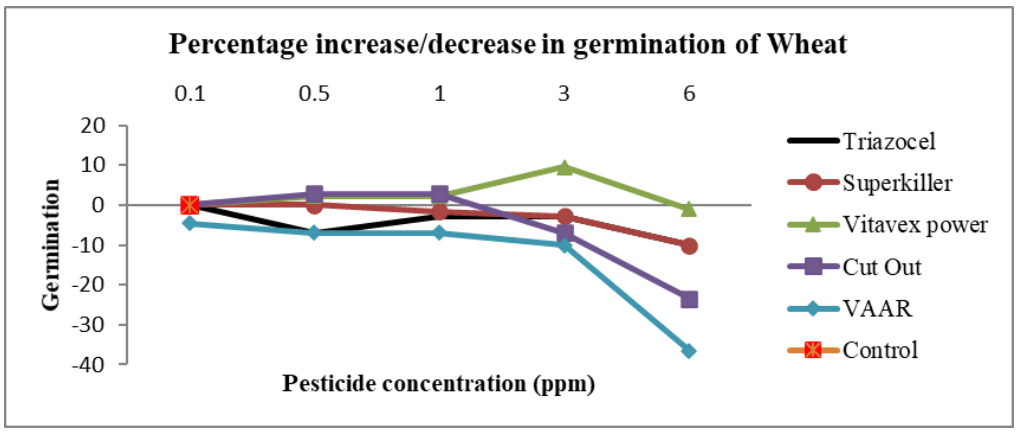

Figure 1 Impact of different concentrations of different pesticides on the germination of wheat Var. Lok-1

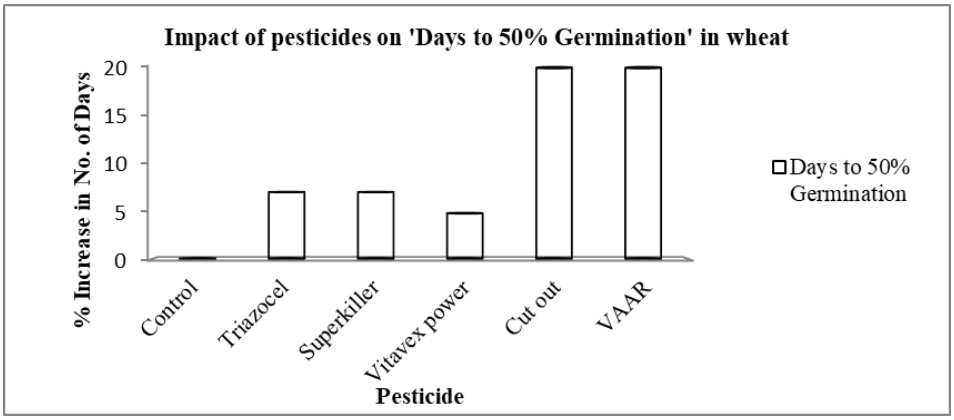

Figure 2 Impact of different concentrations of different pesticides on "Days to 50% germination" of wheat Var. Lok-1

In view of the world's limited croplands and growing population, it is necessary to take all measures to increase crop production in order to ensure food safety [23, 24, 25] and wheat acts not only a cereal crop for human consumption but also a major fodder crop for domestic animals in India. In the present study the impact of different pesticides on the plant length was evaluated. A study [26] observed closure of stomata in benomyl treated plants and lower rate of transpiration in addition to retarded nitrogen assimilation. The cellular endo-membrane system is also known to be sensitive to pesticidal damage and either directly or indirectly results in autolysis [27] and decrease plant growth. In the present study, herbicide VAAR decreased the plant length by the highest amount (27%) resulting in the shortest plants. Lesser toxicity was shown by Superkiller-25 and triazocel which decrease the plant length by 20% and 14% respectively. Vitavax power increased the plant length by 5% at 3ppm concentration and by 2% at double the recommended dose. The most favorable pesticide resulting in 15% increase in plant length was Cutout. 2,4-D is known to act as a plant growth regulator and augments the growth of crop plants usually at lower concentrations.

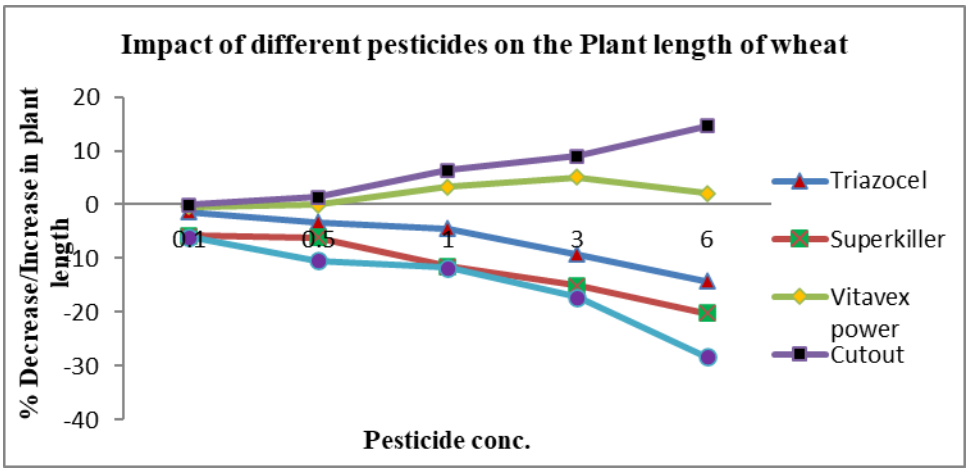

Figure 3 Impact of different concentrations of different pesticides on the Plant length in wheat Var. Lok-1

Pigment suppression due to pesticides is reported by many studies [28, 29]. The present study assessed the chlorophyll content in wheat leaves according to the method of [30]. All the pesticides were found to impact the chlorophyll content of wheat. Except Vitavax power, all the pesticides proved toxic to the buildup of chlorophyll in wheat leaves. Both chlorophyll a and chlorophyll b decreased in direct proportion to the concentration of the applied pesticides. The most toxic pesticide to this pigment was VAAR and the most toxic concentration was 6ppm. Towards maturity of the crop, the decrease in chlorophyll content was statistically insignificant at all the different used pesticides and different concentrations. The recorded inhibition of chlorophyll is probably due to photo-oxidation since the protecting character of carotenoids is disturbed due to pesticide treatment [31].

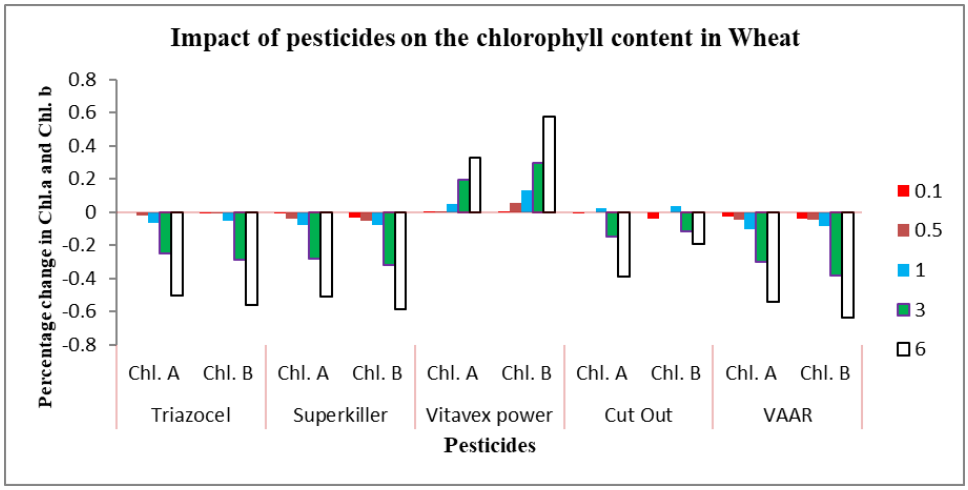

Figure 4 Impact of different concentrations of different pesticides on Chlorophyll content of wheat

Wheat is the staple food crop of majority population of the world after rice and provides both carbohydrates and proteins needed for the normal functioning of human body. The present study assessed the carbohydrate content of wheat using the sulphuric acid-phenol method of [32]. All the concentrations of triazocel, Superkiller-25 and VAAR were found toxic to the buildup of carbohydrates in wheat leaves and seeds however only 6ppm concentration of cutout proved toxic. Vitavax power at all the concentrations escalated the carbohydrate content of wheat. With the increase in Vitavax power concentration, carbohydrate content increased but the increase was insignificant towards the maturation of crop. VAAR was the most toxic pesticide and resulted in aborted seeds at its 3 and 6ppm concentrations. Pesticides are known to induce oxidative stress, leading to generation of free radicals and alteration in antioxidants, oxygen free radicals, the scavenging enzyme system, and lipid peroxidation [33, 34] which often results in the metabolic blockade. The noticeable decrease in carbohydrates and protein content of plants in relation to applied pesticides might be due to the disturbing influence of such toxicants on enzymes involved in carbohydrate metabolic pathway and accumulation of succinate [16, 35].

Table 1 Comparative % increase/decrease in carbohydrate content of wheat on application of different pesticide at different concentrations relative to control

	Triazocel	**Superkiller**	**Vitavax power**	**Cut-out**	**VAAR**
0.1	-0.07	-0.07	0.21	0.21	-0.07
0.5	-0.07	-0.36	0.21	0.21	-0.36
1	-0.36	-0.64	0.50	0.50	-0.64
3	-0.93	-1.21	0.78	0.21	NE
6	-1.49	-1.49	1.07	-0.07	NE

NE- Not evaluated

Protein content of wheat was evaluated using the method of [36, 37]. 0.1ppm concentration of all the used pesticides proved non-toxic. Superkiller and VAAR were toxic above their 0.1ppm concentration while Triazocel was toxic above its 0.5ppm concentration (Table 2). All the pesticides at all the concentrations insignificantly affected the protein content except 6ppm Superkiller and 3 and 6ppm VAAR which significantly decreased the protein content. All the concentrations of Vitavax power stimulated the protein buildup in wheat; however, the increase was insignificant both at 0.01 and 0.05% level of significance.

Table 2 Comparative % increase/decrease in protein content of wheat on application of different pesticide at different concentrations relative to control

	Triazocel	Superkiller	Vitavax power	Cutout	VAAR
0.1	0.00	0.00	0.00	0.81	0.00
0.5	0.00	-0.81	0.81	0.81	-0.81
1	-0.81	-1.61	1.61	1.61	-2.42
3	-2.42	-3.23	3.23	0.81	NE
6	-4.84	-5.65	4.03	0.00	NE

NE- Not evaluated

All the pesticides resulted in decreased number of seeds per plant relative to control. Vitavax power was the least toxic pesticide while VAAR was the most toxic pesticide. Significant decrease in the number of seeds per plant was observed above 1ppm concentration of all the pesticides. The trend of toxicity of the pesticides was VAAR > Cutout > Superkiller> Triazocel> Vitavax power. There was no seed set at 3 and 6ppm concentration of VAAR.

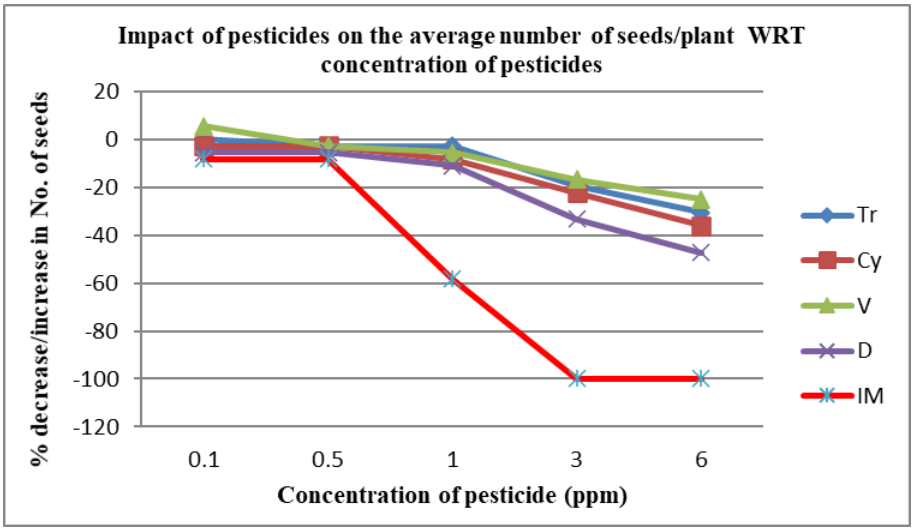

Figure 5 Impact of different concentrations of different pesticides on the average number of seeds per plant in wheat

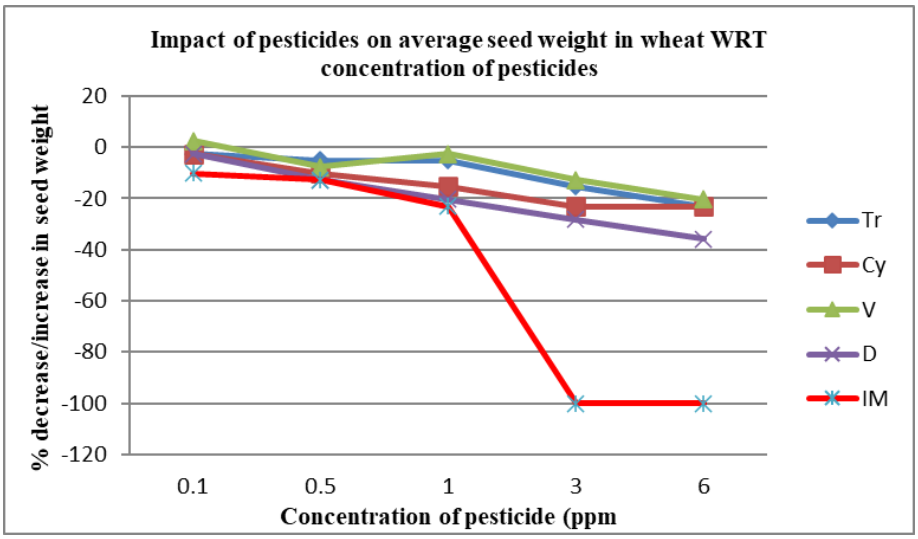

Figure 6 Impact of different concentrations of different pesticides on the average seed weight in wheat

Figure 6 shows a decrease in the average seed weight of wheat on application of all the different pesticides. The toxicity of the pesticides increased with the increase in concentration of the pesticides. The most toxic pesticide was again VAAR and the least toxic pesticide was Vitavax power. All the other pesticide showed intermediate toxicity. At and above 0.5ppm concentration, all the pesticides resulted in significant decrease in the average seed weight in wheat. VAAR at 3 and 6ppm concentrations resulted in aborted seeds.

The inhibition of photosynthetic enzyme system presumably results in the decline of carbohydrate and protein content and also lowers the yield. Toxicity of insecticides [15, 38] is attributed to the stress of these chemicals on the enzyme system of the plants while the herbicides of imidazolinone group are known to inhibit ALS activity consequently resulting in increased free amino acid pool and reduced protein levels [39] moreover rapid decrease in the translocation of photosynthetic assimilates [40] result in dwarfism and carbon starvation [41].

4. Conclusion

The present study evaluated five pesticides for their impact on germination, plant growth, chlorophyll content, carbohydrate content and protein content and also on the yield of wheat. VAAR (Imazethapyr 10%SL) was concluded to be the most toxic pesticide to the crop resulting in lower values for all the studied parameters and above 3ppm concentration resulted in complete abortion of wheat seeds. Vitavax power was non-toxic and contrarily improved wheat qualitatively and quantitatively except at its highest used concentration of 6ppm which had a limited insignificant toxicity. All the other pesticides (triazocel, superkiller-25 and cutout) showed intermediate toxicity and insignificant to significant reduction in studied parameters at varied concentrations. Since the soybean-wheat cropping system in India employs huge quantities of imazethapyr to control pests in soybean, the leftovers in the fields could result in reduction in the wheat yield. The present study bats for evaluation of residual nature of imazethapyr in soybean fields and prescribe to standardize the application rates of this pesticide in soybean to minimize the effects to the succeeding wheat crop.

Compliance with ethical standards

Acknowledgments

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