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Impact of the Pesticides Monocrotophos and Quinalphos on the Morphological Features of Red Amaranth under Arbuscular Mycorrhizal Fungus Inoculation

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Abstract: The present work deals with the impact of Monocrotophos and Quinalphos on the morphological features of Red Amaranth under AM fungus inoculation. The Red Amaranth plants are grown in pots in a split plot design with pesticides levels as main treatments (Recommended leve(0.5), Below recommended level(0.1) and Above recommended level(1.5) ppm) and AM fungus as sub treatments (AM- uninoculated and AM+ inoculated). The experiments were replicated seven times. The Red Amaranth plants are raised in pots. The two pesticides Monocrotophos and Quinalphos were sprayed on 5thday at three different levels. The AM fungus (*Glomus fasciculatum*) were mixed with the sand and applied to the pot soil (10 kg /acre). Pots were irrigated as and when necessary. The plant samples were analysed at three different intervals (10, 20 and 30DAS). The results indicated that the pesticides (Monocrotophos and Quinalphos) application, at the three rates (Recommended level, Below recommended level and Above recommended level) caused reduction in various morphological features of Red Amaranth, such as root and shoot length, total leaf area, fresh weight and dry weight, when applied without AM fungus inoculation. Application of pesticides (Monocrotophos and Quinalphos) at recommended level 0.5 ppm along with AM fungus inoculation only increased the growth and yield of the Red Amaranth.

Key words: Red Amaranth · Pesticides · Monocrotophos · quinalphos · AM fungus · Growth

INTRODUCTION

One of the strategies to increase crop productivity is effective pest management because more than 45% of annual food production is lost due to pest infestation. In tropical countries, crop loss is even more severe because the prevailing high temperature and humidity are highly conductive to rapid multiplication of pests [1]. Thus, the application of a wide variety of pesticides on crop plants is necessary in the tropics to combat pests and vector borne diseases. However, the sporadic use has been leading to significant consequences not only to public health but also to food quality resulting in an impact load on the environment [2]. Inappropriate application of pesticides affects the whole ecosystem by entering the residues in food chain and polluting the soil, air, ground and surface water [3-4].

Increasing incidence of cancer, chronic kidney disease, suppression of the immune system, sterility among males and females, endocrine disorders, neurological and behavioral disorders, especially among children, have been attributed to chronic pesticide poisoning [1]. The use of un-prescribed pesticides in inappropriate doses is not only disturbing the soil conditions but is also destroying the healthy pool of bio-control agents that normally co-exist with the vegetation. These biocontrol agents are the friends of agriculture and hence needs to be neutral and developed by reducing the reliance on chemicals use in agriculture [5].

Organochlorine insecticides, such as DDT, hexachlorocyclo-hexane (HCH), aldrin and dieldrin are among the most commonly used pesticides in the developing countries of Asia, because of their low cost and versatility against various pests [6-7]. Nevertheless, because of their potential for bioaccumulation and biological effects, these compounds were banned in developed nations two and half decades [8-9]. Their resistance to degradation has resulted in contamination, universally found in many environmental compartments. Such residues may be comprised of many substances,

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which include any specified derivatives such as degradation products, metabolites and congeners that are considered to be of toxicological significance.

The agricultural production increased tremendously due to introduction of high-yielding varieties, use of agro-chemicals and improved irrigation facilities [10]. However, there are several constraints for further increase in agricultural production. One of the limiting factors is the increased incidence of pests and disease. On the other hand, increase use of chlorinated non-degradable pesticides have residue in various living systems for prolonged periods of their span and are presumably responsible for a variety of toxic symptoms [11]. Rekha *et al*. [12] reviewed the technology of application of pesticides in India and recommended future strategies for the rational use of pesticides and minimizing the problems related to health and environment due to inappropriate application of pesticides. So the present research work was carried out to know the impact of Monocrotophos and Quinalphos on morphological features of Red Amaranth under AM fungus inoculation.

MATERIALS AND METHODS

The present research work has been carried out in the Botanical garden of Annamalai University to find the impact of Monocrotophos and Quinalphos on the morphological features of Red Amaranth under AM fungus inoculation. Seeds of Red Amaranth were collected from Tamil Nadu Agricultural Research Institute, Palure, Cuddalore. The AM fungal species (*Glomus fasciculatum*) were collected from Department of Agricultural Microbiology, Tamil Nadu Agricultural University, Coimbatore. Monocrotophos and quninolphos were collected from local Agro Centre, Chidambaram, Tamil Nadu. The Red Amaranth plants are raised in pots. The pesticides were sprayed on 5th day on the plants at three different (0.5, 0.1 and 1.5 ppm) concentrations. For experiment purpose, AM fungi were mixed with sand (10 kg/acre) and applied to the pot culture. The experiment is a split plot design with pesticides levels as main treatments (Recommended level (0.5), Below recommended level (0.1) and Above recommended level(1.5) ppm) and AM fungus as sub treatments (AM- uninoculated and AM+ inoculated). The experiments were replicated seven times. Ten seedlings were randomly selected on 10th day from each treatment to record the seedling growth. The growth of the red amaranth seedlings was measured by using a centimeter scale and the values were recorded. The total leaf area was measured by LICOR Photoelectric area meter. Ten seedlings were taken, air-dried and their fresh weights were taken. The same seedlings were kept in a hot air oven at 80°C for 24 h. Then, the samples were kept in desiccators and their dry weight was taken by using an electronic digital balance. The average was expressed in g/seedling.

RESULTS

Root Length: The effect of pesticides and AM fungus on root length of Red Amaranth at various stages of its growth are presented in Table 1. The higher root length (8.43, 16.63 and 27.63) was recorded in AM fungus with recommended level of Monocrotophos application at 10, 20 and 30 DAS. Similarly the lower root length (3.12, 8.33 and 12.44) was recorded in above recommended level of Monocrotophos application at 10, 20 and 30 DAS. The higher root length (8.13, 14.32 and 24.81) was recorded in AM fungus with recommended level of Quinalphos application at 10, 20 and 30 DAS. Similarly the lower root length (3.56, 7.07 and 11.41) was recorded in above recommended level of Quinalphos application at10, 20 and 30 DAS.

Shoot Length: The effect of pesticides and AM fungus on shoot length of Red Amaranth at various stages of its growth are presented in Table 2.The higher shoot length (10.11, 18.16 and 34.61) was recorded in AM fungus with recommended level of Monocrotophos application at 10, 20 and 30 DAS. Similarly the lower shoot length (3.16, 8.44 and 11.56) was recorded in above recommended level of Monocrotophos application without AM fungus inoculation at 10, 20 and 30 DAS. The higher shoot length (10.35, 18.41 and 36.45) was recorded in AM fungus with recommended level of Quinalphos application at 10, 20 and 30 DAS. Similarly the lower shoot length (3.02, 7.83 and 10.04) was recorded in above recommended level of Quinalphos application at 10, 20 and 30 DAS.

Total Leaf Area: The effect of pesticides and AM fungus on total leaf area of Red Amaranth at various stages of its growth are presented in Table 3. The higher total leaf area (18.43, 43.63 and 68.43) was recorded in AM fungus with recommended level of Monocrotophos application at 10, 20 and 30 DAS. Similarly the lower total leaf area (3.51, 10.84 and 16.41) was recorded in above recommended level of Monocrotophos application at 10, 20 and 30 DAS. The higher total leaf area (15.63, 34.61 and 58.13) was recorded in AM fungus with recommended

Table 1: Effect of pesticides on root length (cm/plant) of red amaranth under AM fungus inoculation

	Monocrotophos						Quinalphos					
	Days after sowing											
	10		20		30		10		20		30	
Treatments												
(ppm)	AM (–)	AM (+)	AM (–)	AM (+)	AM (–)	AM (+)	AM (–)	AM (+)	AM (–)	AM (+)	AM (–)	AM (+)
Control	4.02±0.21	6.15±0.31	10.44±0.52	12.13±0.60	18.32±0.91	20.43±1.02	4.02±0.21	6.15±0.31	10.44±0.52	12.13±0.60	18.32±0.91	20.43±1.02
RL(0.5)	6.73±0.33	8.43±0.42	12.82±0.64	16.63±0.83	23.44±1.17	27.63±1.38	6.68±0.33	8.13±0.40	12.01±0.67	14.32±0.71	23.60±1.24	24.81±1.18
BRL(0.1)	5.82±0.29	7.10±0.35	11.41±0.57	14.15±0.70	20.14±1.005	23.41±1.17	5.63±0.26	7.00±0.35	11.60±0.58	13.60±0.68	21.42±1.07	23.62±1.18
ARL(1.5)	3.12±0.15	5.43±0.27	8.33±0.41	10.12±0.50	12.44±0.62	14.63±0.73	3.56±0.16	5.00±0.25	7.07±0.35	9.46±0.47	11.41±0.57	13.41±0.68

Values are mean of seven replications ± Standard deviation, (–): Uninoculated; (+): Inoculated

RL: Recommended Level, BRL: Below Recommended Level, ARL: Above Recommended Level

Table 2: Effect of pesticides on shoot length (cm/plant) of red amaranth under AM fungus inoculation

	Monocrotophos						Quinalphos					
	Days after sowing											
	10		20		30		10		20		30	
Treatments												
(ppm)	AM (–)	AM (+)	AM (–)	AM (+)	AM (–)	AM (+)	AM (–)	AM (+)	AM (–)	AM (+)	AM (–)	AM (+)
Control	5.87±0.29	6.82±0.34	10.40±0.52	11.42±0.57	16.81±0.84	18.63±0.93	5.87±0.29	6.82±0.34	10.40±0.52	11.42±0.57	16.81±0.84	18.63±0.93
RL (0.5)	7.53±0.37	10.11±0.50	16.80±0.84	18.16±0.90	31.03±1.55	34.61±1.73	7.84±0.39	10.35±0.51	16.84±0.84	18.41±0.92	32.80±1.64	36.45±1.82
BRL (0.1)	6.14±0.30	7.14±0.40	14.80±0.74	16.54±0.82	28.42±1.42	31.50±1.57	6.31±0.35	8.93±0.44	15.02±0.75	17.81±0.89	29.32±1.46	34.60±1.73
ARL (1.5)	3.16±0.15	4.45±0.22	8.44±0.42	9.83±0.49	11.56±0.57	12.42±0.62	3.02±0.15	4.83±0.24	7.83±0.39	9.45±0.47	10.04±0.51	12.65±0.63

Values are mean of seven replications ± Standard deviation, (–): Uninoculated, (+): Inoculate

RL: Recommended Level, BRL: Below Recommended Level, ARL: Above Recommended Level

Table 3: Effect of pesticides on total leaf area (cm^2/plant) of red amaranth under AM fungus inoculation

	Monocrotophos						Quinalphos					
	Days after sowing											
	10		20		30		10		20		30	
Treatments												
(ppm)	AM (–)	AM (+)	AM (–)	AM (+)	AM (–)	AM (+)	AM (–)	AM (+)	AM (–)	AM (+)	AM (–)	AM (+)
Control	6.22±0.31	8.10±0.40	14.60±0.73	15.43±0.77	20.81±1.04	23.41±1.17	6.22±0.31	8.10±0.40	14.60±0.73	15.43±0.77	20.81±1.04	23.41±1.17
RL (0.5)	15.84±0.79	18.43±0.21	38.44±2.24	43.63±2.18	64.60±3.23	68.43±3.42	13.52±0.67	15.63±0.78	30.40±1.52	34.61±1.73	56.66±2.83	58.13±2.96
BRL (0.1)	8.44±0.42	10.43±0.52	23.5±1.17	26.81±1.34	32.9±1.64	34.93±1.76	7.52±0.37	8.15±0.47	22.16±0.85	25.00±0.57	27.12±1.38	29.03±1.46
ARL (1.5)	3.51±0.37	5.10±0.25	10.84±0.54	12.13±0.66	16.41±0.82	18.41±0.82	4.00±0.2	6.51±0.35	9.66±0.48	11.43±0.57	15.66±0.78	17.86±0.89

Values are mean of seven replications ± Standard deviation, (–): Uninoculated; (+): Inoculated

RL: Recommended level, BRL: Below Recommended Level, ARL: Above Recommended Level

Table 4: Effect of pesticides on fresh weight (mg/ plant) of red amaranth under AM fungus inoculation

	Monocrotophos						Quinalphos					
	Days after sowing											
	10		20		30		10		20		30	
Treatments												
(ppm)	AM (–)	AM (+)	AM (–)	AM (+)	AM (–)	AM (+)	AM (–)	AM (+)	AM (–)	AM (+)	AM (–)	AM (+)
Control	5.86±0.29	6.45±0.32	10.64±0.53	12.34±0.61	21.43±1.07	24.28±1.21	5.86±0.29	6.45±0.32	10.64±0.53	12.34±0.61	21.4 3±1.07	24.28±1.21
RL (0.5)	8.10±0.40	11.00±0.55	16.34±0.82	18.95±0.97	34.63±1.73	36.45±1.82	8.45±0.42	11.34±0.56	18.63±0.93	21.41±1.07	34.96±1.74	36.43±1.82
BRL (0.1)	6.88±0.34	8.15±0.47	14.63±0.73	16.68±0.84	28.01±1.40	31.45±1.57	7.00±0.35	8.95±0.47	16.84±0.84	17.45±0.87	29.68±1.48	32.63±1.63
ARL (1.5)	4.55±0.23	5.63±0.28	9.11±0.46	10.45±0.52	16.63±0.83	18.77±0.93	4.75±0.23	5.86±0.29	10.43±0.52	11.33±0.56	16.34±0.81	18.43±0.52

Values are mean of seven replications ± Standard deviation, (–): Uninoculated; (+): Inoculated

RL: Recommended level, BRL: Below Recommended Level, ARL: Above Recommended Level

Table 5: Effect of pesticides on dry weight (mg/plant) of red amaranth under AM fungus inoculation

	Monocrotophos						Quinalphos					
	Days after sowing											
	10		20		30		10		20		30	
Treatments (ppm)	AM (–)	AM (+)	AM (–)	AM (+)	AM (–)	AM (+)	AM (–)	AM (+)	AM (–)	AM (+)	AM (–)	AM (+)
Control	1.84±0.09	2.13±0.16	3.66±0.18	4.65±0.37	7.31±0.36	8.41±0.42	1.84±0.09	2.13±0.16	3.66±0.18	4.65±0.37	7.31±0.36	8.41±0.42
RL (0.5)	3.63±0.18	4.45±0.22	5.13±0.25	6.15±0.37	11.43±0.57	13.44±0.67	3.71±0.18	4.95±0.27	6.34±0.31	7.67±0.38	11.68±0.58	13.40±0.67
BRL (0.1)	2.80±0.14	3.40±0.17	4.63±0.23	5.85±0.29	6.63±0.33	8.33±0.46	2.95±0.14	3.68±0.18	5.00±0.25	6.15±0.30	7.16±0.35	8.80±0.44
ARL (1.5)	1.02±0.03	1.45±0.07	2.30±0.11	3.45±0.17	3.10±0.15	4.44±0.22	1.34±0.06	2.45±0.12	2.34±0.11	3.45±0.17	3.10±0.15	4.65±0.23

Values are mean of seven replications ± Standard deviation, (–): Uninoculated; (+): Inoculated

RL: Recommended level, BRL: Below Recommended Level, ARL: Above Recommended Level

level of Quinalphos application at 10, 20 and 30 DAS. Similarly the lower total leaf area (4.00, 9.66 and 15.66) was recorded in above recommended level of Quinalphos application at 10, 20 and 30 DAS.

Fresh Weight: The effect of pesticides and AM fungus on fresh weight of Red Amaranth at various stages of its growth are presented in Table 4.The higher fresh weight (11.0, 18.95 and 36.45) was recorded in AM fungus with recommended level of Monocrotophos application at 10, 20 and 30 DAS. Similarly the lower fresh weight (4.55, 9.11 and 16.63) was recorded in above recommended level of Monocrotophos application at 10, 20 and 30 DAS. The higher fresh weight (11.34, 21.41 and 36.43) was recorded in AM fungus with recommended level of Quinalphos application at 10, 20 and 30 DAS. Similarly the lower fresh weight (4.75, 10.43 and 16.34) was recorded in above recommended level of Quinalphos application at 10, 20 and 30 DAS.

Dry Weight: The effect of monocrotophos and AM fungus on dry weight of Red Amaranth at various stages of its growth are presented in Table 5. The higher dry weight (4.45, 6.15 and 13.44) was recorded in AM fungus with recommended level of Monocrotophos application at 10, 20 and 30 DAS. Similarly the lower dry weight (1.02, 2.30 and 3.10) was recorded in above recommended level of Monocrotophos application at 10, 20 and 30 DAS. The higher dry weight (4.95, 7.67 and 13.40) was recorded in AM fungus with recommended level of Quinalphos application at 10, 20 and 30 DAS. Similarly the lower dry weight (1.34, 2.34 and 3.10) was recorded in above recommended level of Quinalphos application at 10, 20 and 30 DAS.

DISCUSSION

In this study the morphological parameters such as root length, shoot length, total leaf area, fresh weight and dry weight of Red Amaranth are higher in recommended level of pesticides (Monocrotophos and Quinalphos) application supplemented with AM fungus inoculation. Our findings coincide with previous findings that pesticides application increased the growth of various plants such as wheat [13-15] and cocoa [16]. This may be due to the effective control of pests by application of pesticides at recommended level and the supply of requisite amount of certain nutrients by AM fungi for the luxuriant growth of Red Amaranth. In case of sampling days all the parameters were higher in recommended level of pesticide and AM fungus application at 30 DAS plants.

Application of the pesticides (Monocrotophos and Quinalphos) at above recommended level with/without AM fungus (*Glomus fasciculatum*) inoculation decreased the various morphological parameters of the Red Amaranth in all the three sampling days. Similar inhibitory effects of pesticides have previously been reported. MacRae and Alexander [17] found that the growth of alfalfa inhibited by the addition of herbicide to the soil. Bertholet and Clark [18] reported that Trifluralin and Metribuzin reduced the dry mass and nodulation of faba bean plants. Similar results were also obtained by Eberbech and Douglas [19] using the pesticides Paraquat and Glyphosate. The shoot and root dry mass and nodule formation of fababean were also decreased when grown in soil treated with Brominal and Gramoxone, even at field application doses [20]. The effect of these chemicals on plant growth could be direct or indirect. Most reports attribute the inhibitory effect of pesticides on plant growth to the suppression of growth promoting microorganisms in the rhizosphere [21-23]. Deleterious effects of pesticides on root colonization with AM fungi and mycorrhizal spore formation have also been reported earlier. Sreenivasa and Bagyaraj [24] found a reduction in root colonization with AM fungi and spore number by Copper-oxychloride and Carbofuran. Most reports attribute the negative effects of pesticides on root colonization with AM fungi to their effects on mycorrhizal spore germination to initiate infection [25-27].

The decrease in morphological parameters of the plants tested with pesticide application is mainly due to the harmful effects of these chemicals on root colonization with AM fungus (*Glomus fasciculatum*) and the sensitive nature of red amaranth on higher concentrations of pesticides. Single application of Endosulfan at recommended rates does not inhibit plant growth and AM development while two repeated applications at these concentration adversely affects all the parameters except plant height [28]. However two-repeated application of Quinalphos at a level of 0.5 kg ha^{-1} was non-toxic while the 2.5 kg ha^{-1} level exerted toxicity towards plant growth and VAM development. Evidently 5 and 10 kg ha^{-1} levels proved to be toxic for plant growth and AM fungi. Most striking reduction in *G. mosseae* infection was reported with parathion an organophosphorus insecticides [29]. Further analysis for correlation coefficients clearly indicated that there exists a strong positive (r = 70.91) relationship between percent colonization and plant dry weight or total root length of sorghum under the influence of selected insecticides [30]. Abd El-Maksoud *et al*. [31] and Ishac *et al*. [32] have also shown that the colonization of legumes with AM fungi is an important perquisite for adequate yield of plant grown in calcareous soil. Enhancement of growth by AM fungi could possibly be due to phytohormonal production by these microorganisms [26] that may be changed by the action of pesticides.

AM fungi are ecologically important symbiont of most terrestrial plant root system and they are critical component of terrestrial ecosystems and have important effects on nutrient acquisition by most of land plants. It is frequently suggested that AM fungi may improve P nutrition, enhance N uptake and impair disease resistance in their host plants or adaptation to various environmental stresses. These agriculturally important symbiotic microorganisms play a remarkable role in nutrients (N, P and K) and micro elements acquisition [33]. The higher doses of pesticides application not only suppress the plant growth and also the soil microbes. So, in order to mitigate the pesticide toxicity the AM fungal strains were inoculated in to the soil. The AM fungus (*Glomus fasciculatum*) not only improved the red amaranth growth and may also control the pesticide toxicity in soil through accumulation of toxic substances.

In conclusion, the results of this experiment reveal that pesticides (Monocrotophos and Quinalphos) application, at all the three rates (recommended level, below recommended level and above recommended level) caused reduction in plant growth, when applied without AM fungus (*Glomus fasciculatum*) inoculation. The effect could be directly on the plant itself or indirectly on root micro flora. The results indicated that the effect on AM fungi may be the main reason for growth inhibition of plants. Application of pesticides (Monocrotophos and Quinalphos) at recommended level (0.5ppm) along with AM fungus (*Glomus fasciculatum*) inoculation only increased the growth and yield of the Red Amaranth.

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