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Impact of Post-Emergence Application of Dichlorophenoxy Acetic Acid (2,4-D) Herbicide on Growth and Development of Three Weeds Associated with Maize Growth

Hanan. M. Abou El-Ghit*

Botany and Microbiology department, Science Faculty, Helwan University, Cairo, Egypt
*Corresponding author

A B S T R A C T

Post emergence application of 2,4-Dichlorophenoxyacetic acid (2,4-D) as a herbicide even at low concentrations showed an effective control on three weeds (slender amaranth, goosefoot and prickly burweed) associated with maize growth. 2,4-D was applied at 0.0, 125, 250, 500 and 1000 ppm. 500 ppm 2,4-D treatment significantly decreased numbers and fresh weights of the three weeds by 50% approximately. At 1000 ppm 2,4-D, there were sever reductions in weeds numbers, fresh weights and photosynthetic pigments contents of the three weeds. Fresh weights and photosynthetic pigments contents of maize were favored significantly after application of 2,4-D on its associated weeds at all tested rates.

Introduction

Maize (*Zea mays L.*) is the second most important cereal crop in Egypt in terms of total food production. It is grown for fodder as well as for grain. The grains of maize are used in a variety of ways by the human beings. Weeds are a major problem in crop production and drastically decrease crop yield. Weed control is an important management practice to ensure optimum grain yield. Yield losses due to weeds have been reported up to 35 % (Oerke, 2005; Dangwal, *et al.* 2010). The use of herbicides may reduce such losses, as herbicides may reduce the weed infestation provided that the herbicide-treated weeds are not herbicide resistant.

Weed compete with crop plants for soil nutrients, light and water. Slender amaranth *(Amaranthus viridis),* goosefoot *(Chenopodium album)* and prickly burweed *(Xanthium spinosum)* are troublesome broad leaved weeds associate with maize growth (Malik *et al.* 2006). *Amaranthus viridis* is a cosmopolitan weed belong to family Amaranthaceae, *Chenopodium album* is a fast-growing weed belong to Chenopodiaceae, whereas *Xanthium spinosum* is a noxious weed in Asteraceae family.

Some herbicides are synthetic mimics of natural plant hormones (Kellogg *et al.*,

2000). Selective herbicides kill specific targets, while leaving the desired crop relatively unharmed. Herbicide use has undoubtedly contributed to crop yield increases and the efficiency of production (Andrew, 2012). Some substantial benefits can be gained through the use of herbicides to manage unwanted vegetation. Unintended but economically important damage to crop plants is sometimes a consequence of the inappropriate use of herbicides (Robert, 1941 and Mehmeti, 2004). Herbicides have different modes of actions on enzymes (catalysts of biological reactions), this means that the target enzymes may no longer function properly, or at all. Herbicide distort enzymes molecules in some way, so component chemicals for the reaction accumulate and may be directly or indirectly damaging. Absence of the reaction's products will restrict growth, either through starvation of key building blocks or because the reaction makes chemicals which normally protect the plant (Santra and Baumann, 2008).

Over decades, the so-called auxin herbicides had resisted all efforts to elucidate their molecular interactions and the biochemical and physiological basis of their phytotoxicity (Cobb, 1992).

Auxin herbicides started a new era of weed control in modern crop production due to their systemic mobility in the plant and to their selective action, preferentially against dicot weeds in cereal crops (Cobb, 1992 and Grossmann, 2007). Auxin herbicides mimic the action of the main auxin, indole-3-acetic acid (IAA) in higher plants (Cobb, 1992). However, they are long-lasting, particularly due to their higher stability in the plant, and, therefore, more effective than IAA. Auxins stimulate a variety of growth and developmental processes when present at low concentrations at the cellular sites of

action. However, with increasing concentration and auxin activity in the tissue, growth is disturbed and the plant is lethally damaged (Grossmann, 2003).

In general, grasses are much less sensitive to synthetic auxin herbicides than are dicots. So, for example, at the doses used to kill dandelions, grasses are largely unaffected (Cobb, 1992 and Grossmann 2003). Auxin-based herbicides are referred to as "selective" herbicides because they kill so-called "broadleaf" plants (dicots) but not grasses, hence, that's why they're popular herbicides with growers of lawns.

Phenoxy herbicides work by binding to some or all of the same sites in the plant cells as naturally occurring IAA. While naturally occurring IAA concentrations in the cell are highly regulated, when phenoxy herbicides are applied, plant growth becomes deregulated. This deregulation causes twisting, thickening and elongation of leaves and stems and eventually leads to plant death as the plant cannot mobilize reserves, repair or function properly (Song, 2014).

2,4-D was the first compound that, at low doses, could selectively control dicots broadleaf plants, but not most monocots narrow leaf crops like wheat, maize (corn), rice, and similar cereal grass crops (Andrew *et al.*, 2010). 2,4-D generally has low toxicity for humans (Aylward, 2010).

Materials and Methods

A pot experiment was carried out to examine the effect of foliar application of 2,4-Dichlorophenoxyacetic acid (2,4-D) as a herbicide on the growth of three weeds (slender amaranth*,* goosefoot and prickly burweed) which grow associated with maize plant. 2,4-D was applied at different

concentrations (0.0, 125, 250, 500 and 1000 ppm). Seeds of *Zea mays* var. amylacea and the three weeds were obtained from the Agriculture Research Center, Ministry of Agriculture, Giza, Egypt. Maize and weeds were grown in pots (40 cm in diameter) of 15 kg of clay loamy soil.

Fifteen seeds of each weed were sown with ten seeds of maize. 2,4-D was sprayed on weeds with a hand sprayer after 2 weeks of sowing and repeated after one week. Precautions were taken to avoid damage of maize plant. There were three replicates of each treatment of 2,4-D. Irrigation was done regularly to maintain soil field capacity. The effect of 2,4-D herbicide was measured after five weeks of sowing by counting of slender amaranth, goosefoot and prickly burweed numbers (plants/pot) and estimation of fresh weights of each weed (g/ 3plants). Also, fresh weight (g) of maize plant was estimated after 2,4-D application on the associated weeds. Chlorophyll a, b and carotenoids contents in the fresh leaves of weeds and maize (mg/g. F.W) were determined in samples according to Metzener *et al.*, (1965). Data were statistically analyzed by Snedecore and Cochran (1981) method.

Results and Discussion

Tables (1 and 2) indicate that 2,4-D herbicide controlled both number and fresh weights of slender amaranth, goosefoot and prickly burweed plants even at low rates. 500 ppm 2,4-D treatment led to approximately 50% reduction in plant numbers and plants fresh weights. Few plants of the slender amaranth, goosefoot and prickly burweed plants survived at 1000 ppm 2,4-D, but they were very small and damaged. Concerning the photosynthetic pigments content of weeds, it was found that chlorophyll a, b and carotenoids of 2,4 D sprayed weeds were considerably diminished compared with

their corresponding controls and this effect was in a concomitant trend with that of growth parameters in response to 2,4-D treatments (Tables 3,4,5). The lowest pigments content was recorded by the highest 2,4-D concentration (1000 ppm).

The reducing effect of 2,4-D on slender amaranth, goosefoot and prickly burweed plants may be a consequence effect of increasing the endogenous auxin concentrations to supraoptimal and extensive perception by auxin receptors (Badescu, 2006 and Dharmasiri *et al.* 2005). Also, it may be attributed to stimulation of ethylene production which trigger the overproduction of abscisic acid (ABA), causing its accumulation. Over production of ethylene causes number of plant responses, including epinasty and senescence.

Accumulated ABA in the shoot tissue is translocated within the plant and mediates events in the auxin herbicide syndrome, such as growth inhibition, tissue decay and plant death. The recent identification of receptors for auxin perception and the discovery of a new hormone interaction in signalling between auxin, ethylene and the upregulation of abscisic acid biosynthesis account for a large part of the repertoire of auxin-herbicide-mediated responses, which include growth inhibition, senescence and tissue decay in sensitive dicots (Chae *et al.* 2005).

Stimulation of ethylene biosynthesis plays a key role in eliciting the herbicidal symptoms in sensitive plants (Grossmann, 2010). These results are in agreement with Hansen and Grossmann (2000), Grossmann (2003) and Kepinski *et al*. (2005)**.** Chae (2005) reported that ethylene is a factor in defoliation caused by 2,4-D. Because plants can't break down 2,4-D, it's action persists.

Table.1 Effect of 2,4-D Application on Numbers of Slender Amaranth,
Goosefoot and Prickly Burweed

2,4-D conc. (ppm)	Plant numbers/pot		
	Slender amaranth	Goosefoot	Prickly burweed
0.0	15	15	15
125	13.6	12.3	13.3
250	11.3	9.6	10.6
500	9.3	7.3	9.3
1000	3.3	4.6	5.3
L.S.D. at 5%	0.51	0.92	0.82
L.S.D at 1%	1.30	1.83	1.73

Table.2 Effect of 2,4-D Application on Fresh Weights of Slender Amaranth,
Goosefoot and Prickly Burweed

2,4-D conc. (ppm)	Fresh weights (g/ 3 plants)		
	Slender amaranth	Goosefoot	Prickly burweed
0.0	5.56	6.01	5.09
125	3.78	5.13	3.42
250	2.23	3.88	2.33
500	1.78	2.03	1.58
1000	0.84	0.91	0.77
L.S.D. at 5%	0.063	0.067	0.059
L.S.D at 1%	0.081	0.091	0.078

Table.3 Effect of 2,4-d Treatments on Chlorophyll "a" Content (mg/g. Fresh weight)
in Leaves of Slender Amaranth, Goosefoot and Prickly Burweed

| 2,4-D conc. (ppm)	Chl. a (mg/g. f.wt)		
	Slender amaranth	Goosefoot	Prickly burweed
0.0	3.753	3.971	2.953
125	3.013	3.123	2.222
250	2.345	2.133	1.791
500	1.326	1.544	0.987
1000	0.439	0.533	0.418
L.S.D. at 5%	0.035	0.052	0.035
L.S.D at 1%	0.057	0.083	0.046

Table.4 Effect of 2,4-D Treatments on Chlorophyll "B" Content (Mg/G Fresh Weight) in Leaves of Slender Amaranth, Goosefoot and Prickly Burweed

2,4-D (ppm)	Chl. b (mg/g. f.wt)		
	Slender amaranth	Goosefoot	Prickly burweed
0.0	2.53	2.83	2.31
125	1.66	2.06	1.62
250	1.01	1.33	1.01
500	0.71	0.51	0.81
1000	0.029	0.027	0.033
L.S.D. at 5%	0.033	0.017	0.055
L.S.D at 1%	0.047	0.029	0.071

Table.5 Effect of 2,4-D Treatments on Carotenoids Content (Mg/G Fresh Weight) in Leaves of Slender Amaranth, Goosefoot and Prickly Burweed

2,4-D (ppm)	Carotenoids (mg/g.f.wt)		
	Slender amaranth	Goosefoot	Prickly burweed
0.0	1.75	1.49	1.56
125	1.05	1.07	1.09
250	0.96	0.90	0.72
500	0.71	0.57	0.44
1000	0.36	0.31	0.27
L.S.D. at 5%	0.021	0.019	0.051
L.S.D at 1%	0.041	0.028	0.073

Fig.1 A Maize Fresh Weight (g) and (B) Chlorophyll a, b and Carotenoids Contents (mg/g.f.wt) of Maize Leaves after 2,4-d Application on its Associated Weeds. L.S.D at 5% for F.wt, Chl a, Chl b and Carotenoids: 0.46, 0.0.065, 0.044, 0.035

(A)   (B)
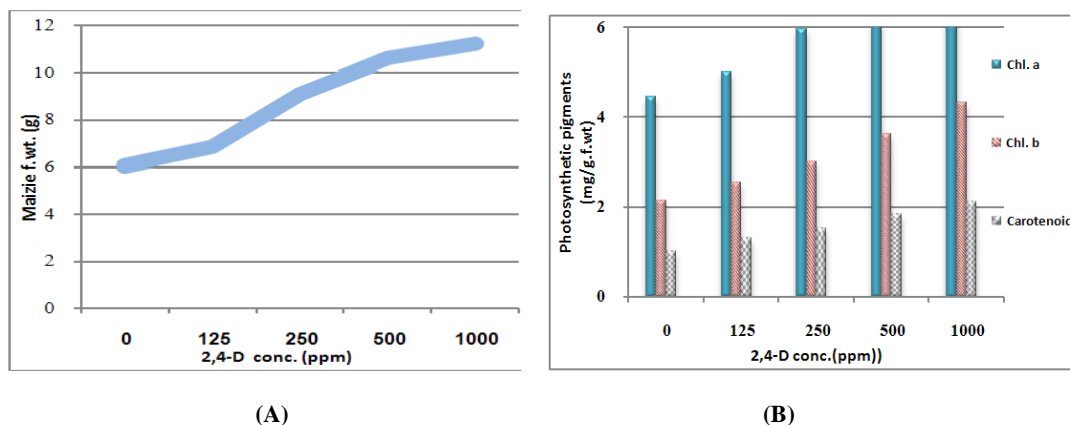
Auxin herbicides and IAA are directly able to trigger activation of NCED (9-cis-epoxycarotenoid dioxygenase) gene, which in turn participate in ABA biosynthesis and accumulation (Hamner and Tukey 1944). In addition, NCED gene expression and activity appears to be stimulated by auxin-induced ethylene, leading to lasting ABA biosynthesis (Sterling and Hall, 1997) and Kraft *et al*. (2007). Taylor *et al*. (2005) reported that, ABA biosynthesis is induced in the shoot tissue of Arabidopsis by increasing xanthophyll cleavage, leading to increased production of the ABA precursor, xanthoxin. Xanthoxin production which is a key regulated step in the ABA pathway is catalyzed by the plastid enzyme NCED (9-cis-epoxycarotenoid dioxygenase), which is encoded by a family of NCED genes. NCED genes were assumed to be regulated by auxin treatment. Auxin treatment enhanced NCED precursor supply, hence, contribute consequently to ABA accumulation (Symonds *et al.,* 2005; Raghavan *et al.,* 2006). Walsh *et al*. (2006) and Grossmann, (2007) reported that, 2,4-D treated Arabidopsis showed that, expression of NCED genes are involved in biosynthesis and accumulation of abscisic acid.

Data presented in Fig. 1 A & B indicate that maize fresh weight (g) and photosynthetic pigments content (mg/g.f.wt) were favored significantly after application of 2,4-D on its associated weeds at all tested rates. The increasing of maize fresh weight and photosynthetic pigments content of maize leaves after 2,4-D application on its associated weeds may be attributed to the controlling of weed growth and decreasing competition between maize and its associated weeds on soil nutrients, water and light. Also the undamaging of maize may be attributed to its resistance. This agrees with Abdullah *et al*. (2007), Khan and Haq

(2004), Bogdan (2007) and Dangwal, *et al.* (2010) who recorded a strong enhancement of photosynthetic pigments content (mg/g.f.wt) of maize crop after 2,4-D application on its associated weeds. Grasses are more resistant to such herbicides because of differences in leaf morphology, translocation of the herbicide inside the plant, and the ability to metabolize (breakdown) synthetic auxins (Mehmeti and Demaj, 2010).

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