

SOME VEGETABLE RESPONSES TO CHLOROPHENOXY HERBICIDE EXPOSURE

J. R. ORSENIGO

Associate Horticulturist

Everglades Experiment Station

Belle Glade

The most useful and widely used chlorophenoxy herbicide is 2,4-D¹ (2,4-dichlorophenoxyacetic acid), a powerful tool for broadleaf plant destruction. At low dosages, 2,4-D also causes useful regulatory or stimulatory effects which include intensification of skin color of red potato varieties and regulation of citrus thinning and fruit sizing.

Because of its *toxicity*, the capability of causing plant injury, 2,4-D is recommendable for certain weed and brush control practices. These practices entail certain *hazards* through unintentional exposure of sensitive plants. Field use of 2,4-D has resulted in damage to sensitive agronomic and horticultural crops both near and distant from areas actually sprayed. Use hazards² have been discussed elsewhere (5, 7).

LITERATURE

The effects of chlorophenoxy herbicides on plants have been researched carefully in many laboratory, greenhouse and field experiments during the past 20 years. The anatomical and morphological responses to research dosages have been reported (10) and have been summarized recently (1). Effects of dosages sufficient for plant destruction are too numerous to cite. Relatively few accounts of crop plant injury syndromes from sub-lethal chlorophenoxy herbicide exposure exist in the literature (11, 12).

Research in field responses to simulated drift exposure of chlorophenoxy chemicals may be futile in many areas through accidental contamination by wayward herbicide. In Iowa, 2,4-D apparently is a normal component of summer atmosphere (2). A similar problem exists in some areas of Florida.

FACTORS AFFECTING CROP RESPONSE AND EVALUATION OF INJURY

Sensitive crop plants are exposed largely through drift of chlorophenoxy herbicides from the site of application during spraying operations. The details of the spraying operation determine the degree of crop exposure: i.e., specific chemical and formulation, carrier, spray volume and pressure, acreage sprayed, distance between sprayed area and crop plants, wind direction and velocity. The crop species, age and development, cultural conditions, climatic environment and metabolic conditions govern the response to the exposure (13).

Under usual drift conditions it is almost impossible to estimate accurately the intensity of exposure in terms of customary dosage rates. Frequently, symptoms are so mild or rare that they are undetected. Older plant growth is affected only by massive doses while definitive symptoms may not be expressed until new growth has had opportunity to develop. Apparent recovery through development of new, normal plant organs may mask the severity of exposure.

Reliable diagnosis depends on repeated observation of the plant syndrome. Formative symptoms do not develop promptly^{3 4 5} (4).

Evaluation of plant injury syndromes is complicated by possible confusion of chlorophenoxy herbicide symptoms with those of viruses,⁶ fertilizer imbalances,⁷ pesticide spray injury (6), climatic effects (13) or combinations of these.

RESPONSIVE PLANT ORGANS

Symptoms of chlorophenoxy herbicide exposure are varied and complete syndromes are rare.

³Orsenigo, J. R. 1958. Primary evaluation of post-emergence applied herbicides in vegetable and field crops, Spring, 1958. Everglades Station Mimeo Report 59-6.

⁴..... 1962. Primary evaluation of pre-planting and of pre- and post-emergence applied herbicides in vegetable and field crops, Spring, 1962. Everglades Station Mimeo Report 63-1.

⁵..... 1963. Primary evaluation of preemergence and postemergence applied herbicides in vegetable and field crops, Spring, 1963. Everglades Station Mimeo Report EES64-3.

⁶Campbell, R. N., R. G. Grogan and K. A. Kimble. 1964. Big vein of lettuce. Calif. Agr. 18(3): 6-8.

⁷Peck, N. H., R. F. Sandsted, D. J. Lathwell and T. E. Schultz. 1963. Potassium deficiency of snap beans. Farm Research (N.Y.) 29(3): 8, 9.

University of Florida Agricultural Experiment Stations Journal Series No. 1983.

¹Plant responses to 2,4-D are typical of other chlorophenoxy herbicides, MCPA, 2,4,5-T, silvex and the butyric acid analogues. This group will be represented by 2,4-D herein.

²Orsenigo, J. R. 1963. Use 2,4-D Safely. Everglades Station Mimeo Report EES64-12.

Common epinastic responses usually occur soon after exposure and may not persist. Formative responses may not be evident in organs fully developed at exposure but become apparent as younger tissues develop. General morphological effects have been reported (4). Typical symptoms following drift exposure are:

Roots rarely develop definite symptoms from low intensity drift exposure. More intense exposures close to a sprayed site may cause galling or scarring of cruciferae roots.

Stem responses are common and include curvature, elongation, fasciation, ribbing, thickening, tumorous proliferation or blistering, aerial root development and branching.

Branch responses similar to those of stems usually follow epinasty.

Nodes may thicken, become brittle and develop surface proliferations.

Petiole symptoms usually begin with epinasty which may be followed by thickening, ribbing and fasciation.

Leaves and *leaflets* respond similarly, frequently with epinastic curvatures, downward cupping and marginal frilling. Leaf form is changed through differential apical and lateral development so that the most severely affected leaves are long and narrow. Leaf tips often appear drawn out into a point. The midrib and veins frequently become pronounced while the interveinal area becomes thickened, coarse, and rough. The leaf blade may appear dimpled or puckered. Leaves may fuse partially or completely.

Floral responses may not be readily apparent and may include fused parts, sterility and abscission.

Fruit may develop abnormally with asymmetrical halves, parthenocarpy, and external scarring. Fruit size may be altered and fruit may absciss.

Field exposures are rarely lethal but may cause delayed maturity, reduced total yield and lowered quality (8).

TYPICAL CROP RESPONSES

Repeated field observations of sensitive crop plants after accidental chlorophenoxy herbicide (especially 2,4-D) exposure are conducive to developing response syndromes even though some experimental elements are lacking. The author has had opportunity to observe the results of these exposures and has attempted to list typical symptoms.

Responses following field exposures are listed below for crops representing 4 botanical families. Some of the observed symptoms correspond to those in the literature (5, 8, 9, 11, 12). Numbers in parentheses accompanying specific symptoms refer to these.

Compositae: Head Lettuck.—Plant wilting; abnormal (11), curled or cupped leaves with pronounced veination; thickened and twisted midribs are common leaf symptoms. Plants exposed when young develop openly without head formation. Leaves fail to "cap" properly or loose heads develop in older plants. Distortion of midribs and leaves often causes the plant to appear triangular rather than round when viewed from above.

Cruciferae: Cabbage.—Plant wilting; occasional frilling and leaf margin serration at apex; petiole epinasty (12); thickening (12) and twisting (9) of the base of the petiole generally follow exposure of young plants. Heads may form openly or loosely with a tendency toward pointing (9, 12). Axillary buds may develop into small "heads" inside mature cabbage with normal external head appearance. Root and stem galling (9, 12) have not been observed from drift exposures.

Cruciferae: Radish.—Plant wilting; occasional leaf distortion and thickening; petiole epinasty; thickening and twisting of petiole bases; and swelling of the stem between the cotyledons and the cotyledonary leaves often occur in young plants. Roots of young plants may elongate and have vertical scars or scabs while red pigmentation may be bleached from the lower halves of maturing roots.

Leguminosae: Snap bean.—Plant wilting (5); leaf deformation, downward cupping, frilling and puckering (5); thickened midribs and veins associated especially with occasional long, narrow strap leaves; partial leaf fusion; petiole epinasty and thickening and distortion of base of trifoliate leaf petioles; branching (5), thickening and ridging of stem; and stem swelling between the cotyledonary leaves and first trifoliate leaves have been observed. Flowering and fruit set may be enhanced or reduced by chlorophenoxy herbicides. Pods may be short and misshapen with occasional external scab or scar formation. Internal seed cavities may lack seed.

Leguminosae: Pole bean.—Symptoms are similar to snap bean. Young pole bean leaves on climbing vines often develop puckering or blistering of interveinal areas after light exposures.

Leguminosae: Southern pea.—Leaves readily develop thickened midribs and veins and are

often straplike: veins tend to run on the soil; flowering may be retarded; and, occasional seed cavities are empty. The southern pea is more sensitive than the snap bean and leaf symptoms may develop at chlorophenoxy doses which initiate no response to tomato.

Solanaceae: Pepper.—Younger plants usually manifest more uniform leaf symptoms which include: epinasty; downward cupping; asymmetry; marginal frilling; puckered interveinal areas; prominent midrib and vein development; and, strapleaf. Symptoms in new foliage which develops may grade off to normal. Plants may wilt and become stunted; uneven development is common. Stems and branches may become thickened and ribbed while older plants may have pronounced basal shoot development. Flowers may absciss after exposure to chlorophenoxy herbicides. Small fruit may absciss or may develop abnormally depending on age at exposure. The most common pod abnormality is tapered or pointed fruit, usually thin walled, which lack symmetrical and complete development of the placenta (inner ribs). Fruit may develop a broad, blunt nipple at the apex which differs from the narrow inclined rod which follows cold exposure. Styles frequently remain attached until harvest. Deformed fruit often lack normal seed development. In occasional, extreme cases, the fruit shoulder or upper side may be open, exposing placenta and seed.

Solanaceae: Tomato.—Petiole epinasty and downward bending of leaves are early chlorophenoxy symptoms in tomato. Further leaf responses include marginal frilling; pointing and thickening; puckered interveinal areas; pronounced veination; and strapleaf. Foliage which develops some time after exposure may be normal. Occasionally plant wilting has been observed. Stems may become blistered with tumorous proliferations; these raised growths are often seen on the upper side of prostrate lower stems and branches. Flowers may absciss. Fruit may be elongated, apple-, plum- or heart-shaped (5) and ribbed, with broad, blunt apical nipples (8). Often, fruit are asymmetrical and retain the style. Internal symptoms include: overdeveloped placental tissue and lack of locules, pulp and/or seed (8). Usually all fruit on a hand are affected and fruit with external symptoms frequently have internal abnormalities.

SUMMARY

Vegetable responses to drift exposures of chlorophenoxy herbicides (2,4-D type) in the field may be variable since symptoms are dependent upon crop species and growth stage as well as intensity and manner of exposure. Development of visible formative symptoms requires continued growth of the plant; symptoms may be mitigated by climatic and cultural conditions. Exposed plants may not develop definitive symptoms and responses may be masked by normal growth some time after exposure. Complete chlorophenoxy herbicide syndromes are rare. Evaluation of symptoms may be confused with plant reactions to other causal agents.

Plant organs which may develop symptoms include: roots, stems, branches, nodes, petioles, leaves and leaflets, flowers and fruit. Greatest interest is in responses associated with vegetable abnormalities, especially those affecting crop maturity, production and quality. Responses observed in head lettuce, cabbage, radish, snap bean, pole bean, southern pea, pepper and tomato are reported herein.

LITERATURE CITED

1. Andus, L. J., Editor. 1964. The physiology and biochemistry of herbicides. Academic Press. p. i-xix, 1-555. Illus.
2. Cole, A. W. and E. L. Denisen. 1964. Herbicidal injury studies with horticultural crops II. Weed Soc. Amer. 1964 Meeting Abs. p. 91-92.
3. Hall, W. C. 1951. Morphological and physiological responses of carnation and tomato to organic phosphorus insecticides and inorganic soil phosphorus. Plant Physiol. 26:502-524.
4. Holly, K. 1954. Morphological effects on plants due to damage by growth-regulator weed-killers. Plant Path. 3(1):1-5.
5. Linn, M. B., F. W. Slife, and B. J. Butler. 1959. Prevent 2,4-D injury to crops and ornamental plants. Univ. of Illinois Circ. 808. p. 1-16.
6. McIlrath, W. J. 1950. Cotton-leaf malformations induced by organic phosphate insecticides. Bot. Gaz. 112: 221-225.
7. Orsenigo, J. R. 1963. Crop damage: A hazard of herbicide use. Hyacinth Control Jour. 2:15, 16, 20.
8. Robbins, Wayne A. and William S. Taylor. 1957. Injury to canning tomatoes caused by 2,4-D. Proc. Amer. Soc. Hort. Sci. 70:373-378.
9. Stoner, Warren N. 1951. A 2,4-D chemical causes unusual injury to cabbage. Plant Dis. Rptr. 37(7):327, 328.
10. Watson, Donald P. 1948. An anatomical study of the modification of bean leaves as a result of treatment with 2,4-D. Amer. J. Bot. 35:543-555.
11. Way, J. M. 1962. The effects of sub-lethal doses of MCPA on the morphology and yield of vegetable crops. I. Lettuce. Weed Res. 2:233-246.
12. Way, J. M. 1963. The effects of sub-lethal doses of MCPA on the morphology and yield of vegetable crops. II. Cabbage, Cauliflower and Brussels Sprouts. Weed Res. 3:11-25.
13. Weaver, M. L. and R. E. Nylund. 1963. Factors influencing the tolerance of peas to MCPA. Weeds 11: 142-148.