Disease control. Partial or perhaps nearly complete control of watermelon mosaic in south Florida might be effected by the elimination of infected plants of *M. pendula* from the rubble piles at the edge of fields of cucurbitaceous crops. This would include all fields of watermelon, squash, cucumber, and cantaloupe. Such a program of elimination of this weed species, by herbicides or other means, is recommended for any south Florida areas where *M. pendula* is found and cucurbitaceous crops are grown.

The epidemiology of watermelon mosaic in central and north Florida is not well enough understood at this time to contemplate any control measures.

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MORPHOLOGICAL AND GROWTH-RETARDING EFFECTS OF 1-AMINO-2-NITROCYCLOPENTANE -1-CARBOXYLIC ACID (ANCPA) ON CERTAIN VEGETABLE CROPS

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ABSTRACT

ANCPA applied as a foliar spray or by plant injection caused severe stunting and morphological modification in a variety of vebetable crops. The morphological changes generally included narrowing and twisting of leaves and an abnormality in tomato fruits that closely resembled the catface disorder. In addition to changes in leaf shape, ANCPA caused a chlorotic condition to occur in leaves developing after treatment. A green netting of veinlets was frequently observed. The effects of ANCPA were reversed by the simultaneous application of L-leucine as a spray and drench.

INTRODUCTION

Growth-modifying effects of amino acid analogs have been reported for many crop species and many amino acids (1, 2, 5, 7, 8). Changes in morphology and growth rate have been shown to be due to interference with the normal metabolism of natural amino acids by structural analogs acting as antimetabolites (1, 7). There is considerable evidence to implicate soil microorganisms as producers of antimetabolites of amino acids that may cause physiological disorders in the field (5, 8, 9) or under controlled experimental conditions (10).

ANCPA has been shown (1, 2, 10) to be a potent antimetabolite of L-leucine, thereby affecting many biological systems. ANCPA is produced by certain isolates of *Aspergillus wentii* Wehm. and has been shown to be capable of reproducing the syndrome of yellow strapleaf of chrysanthemum (10).

The present work was undertaken to obtain information on potential effects on vegetable crops of the naturally-occurring ANCPA, the mode of action, and possible corrective measures for such disorders.

METHODS AND MATERIALS

A screening test was carried out with 20 vegetable plant species as well as other species

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to determine the responsiveness to foliar spray applications of ANCPA. Triplicate treated and triplicate control plots were grown in the field and appropriate plots were sprayed with 100 ppm ANCPA 6 weeks after seeding or transplanting. Plots were fertilized on alternate weeks with 8-8-8 mixed fertilizer at the rate of 400 lbs/a. Pesticide sprays were applied only when required to prevent serious plant damage. Plants were observed regularly for degree and character of effect as well as the longevity of continuation of the adverse effects.

Seedlings for the antimetabolite experiment were grown in the greenhouse in 4-inch plastic pots filled with a mixture composed of three-fourths methyl bromide-treated soil and one-fourth expanded vermiculite. A complete 20-20-20 soluble fertilizer with secondary elements and *microutrients* was applied weekly, 0.125 grams in 50 ml water per pot at each application. Seedlings were grown to heights of 12 to 18 cm at which time ANCPA dissolved in 2 to 10 microliters of water was injected with glass microsyringes into the stems just below the lowermost true leaves. Test plant varieties used were bean —'Harvester', tomato—'Floradel', chrysanthemum—'Iceberg', sunflower—'Greystripe' and tobacco—'Kentucky 56'. L-leucine, used to counteract th eeffects of ANCPA was used as a foliar spray and soil drench to assure maximal uptake by the test plants.

Results

The 20 vegetable species studied were divided (Table 1) into 3 groups according to the response to a foliar spray application of ANCPA. Six species were affected severely, with long-lasting effects (2 to 4 weeks). These plants eventually resumed normal growth but many of the growth deformities in the older leaves were irreversible. Seven species showed no response to the ANCPA spray application.

The symptoms produced in the affected species included chlorsis of expanding leaves, a failure of the growing leaves to expand laterally thereby causing a narrowed appearance, and sometimes a green netting produced by green veinlets surrounding areas of chlorotic leaf lamina. The groupings listed in Table 1 will hold true only for the experimental conditions and growth conditions pertaining in the experiment reported because of the frequently observed fact that

Table 1. Nature of response to foliar sprays* of 1-amino-2-nitro-cyclopentane-1-carboxylic acid (ANCPA)

Severe, long-lasting	Moderate, transient	No apparent effect
Bean	Cucumber	Beet
Cantaloupe	Eggplant	Cabbage
Spinach	Kale	Lettuce
Southern Pea	Okra	Radish
Tomato	Pea	Rutabaga
Watermelon	Pepper	Sweetcorn
	Squash	Turnip

*Sprays were applied at 100 ppm concentration of ANCPA

stage of growth, growth rate, and cultural conditions may alter the response significantly. It is only in developing plant organs or in those rapidly synthesizing chlorophyll that the response is readily apparent. In addition to the effect on leaves, there was a retardation in stem elongation closely associated with the development of other symptoms. A longitudinal stem splitting was observed in watermelon sprayed with ANCPA. Small tomato fruits (1-2 cm in diameter) developed severe catface in about 50% of the fruits that were sprayed. Injection of 10-25 micrograms of ANCPA into the peduncle of fruit hands bearing similar fruit caused catface development in all of the fruits on each hand injected. The catface was moderate to severe. Uninjected fruit hands had very little catface. Naturally occurring catface in control fruit hands was not severe. Flower development was noticeably altered in one of the non-vegetable test species, morning glory. The effected flowers had narrowed and twisted petals and were polypetalous instead of gamopetalous. In cases of less severe response the petal margins of the trumpet-shaped flowers had indentations.

ANCPA was very effective in producing growth-retardation when injected into the stems

Table 2. Reversal by L-leucine* of stunting effects** of 1-amino-2-nitrocyclopentane-1-carboxylic acid (ANCPA) in bean, tomato, chrysanthemum, sunflower and tobacco.

Micrograms ANCPA Injected	Bean (7 days)		Tomato (4 days)		Chrysanthemum (7 days)		Sunflower (3 days)		Tobacco (11 days)	
	0 Leu	+ Leu	0 Leu	+ Leu	0 Leu	+ Leu	0 Leu	+ Leu	0 Leu	+ Leu
	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
0	213	211	29	28	25	30	62	67	99	145
5	123	247	12	27	23	16	39	53	81	120
10	110	171	12	22	13	25	30	45	55	100
15	51	141	15	24	11	21	25	55	16	92
25	30	134	13	29	10	22	16	48	19	40
LSD, .05		46		13		8		30		36

*131 mg L-leucine (Leu) per plant, spray and drench
**Data are given in terms of height increase for a given number of days.

of seedlings of 5 plant species (Table 2). Height increase increments were used as a measure of the degree of effect of varied amounts of ANCPA and of any effects of L-leucine in preventing the growth retardation. An examination of the data in Table 2 indicates that for bean, tomato, chrysanthemum, sunflower, and tobacco, ANCPA probably acts as an antimetabolite of L-leucine. It was observed that L-leucine also prevented or reduced the severity of the typical ANCPA effects of narrowing and yellowing leaves. ANCPA injected into seedlings of the plant species in Table 2 caused the development of very defective leaves. The leaves were narrowed to the extent of appearing string-like with the higher amounts of ANCPA (15 and 25 micrograms per seedling).

Discussion

ANCPA is a very potent toxin capable of disrupting growth and normal morphological development of many plant species. Since it is of natural occurrence, being produced by the fungus *Aspergillus wentii* Wehm., it may under unusual soil and climatic conditions cause disorders of the type described as frenching of tobacco as well as the similar disorders in tomato, squash, ragweed and sorrel (4). There is reason to suspect other microorganisms such as *Bacillus cereus* (5) as being possibly implicated in natural disorders of the type under discussion.

The observation that catface symptoms in tomato fruit are reproduced by ANCPA is of considerable interest. While there is no demonstrated link between the toxin and naturally-occurring catface, there is still the strong possibility that the mode of action of ANCPA may lead to an understanding of the nature of the processes leading to catface development and thereby to some control measures.

The observation that ANCPA is more effective against certain species of plants and against certain growth stages may permit the development of further evidence as to the mode of action. The endogenous supply of L-leucine may be greater in some species than others and at some growth stages compared with others. Larger amounts of native L-leucine should render plants less susceptible to the effects of an antimetabolite. Another possibility is that certain plants may not be susceptible to ANCPA effects because of the lack of enzyme systems that will incorporate the antimetabolite into protein or peptides. If the ANCPA remains in a free state, with no substitution of L-leucine, no harm will be done in terms of interfering with normal leucine metabolism and protein synthesis.

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