CARBAMATE HERBICIDES

Evaluation of Three Carbamate Herbicides in Comparison with Isopropyl *N*-(3-Chlorophenyl) Carbamate

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Isopropyl *N*-(3-methylphenyl) carbamate (I), *sec*-butyl *N*-(3-chlorophenyl) carbamate (II), and isopropyl *N*-(2-methoxy-5-chlorophenyl) carbamate (III) were compared to isopropyl *N*-(3-chlorophenyl) carbamate (CIPC) in greenhouse pre-emergent tests on cotton, soybeans, green beans, oats, crabgrass, and chickweed on three types of soil. The relative effectiveness of the materials was compared on the basis of pounds per acre of chemical required to produce a 50% growth inhibition. These carbamates possessed considerable herbicidal activity. In general, compounds I and II were close to isopropyl *N*-(3-chlorophenyl) carbamate in activity, while compound III was somewhat less active. The type of soil used as a planting medium had a pronounced effect on the initial activity of the compounds, which were more active in sand than in loam. The period of residual effectiveness appeared to be a function of the soil type, but also depended on the dosage of chemical applied.

Esters of N-substituted phenyl carbamic acids have been attaining ever-increasing importance in agriculture as selective herbicides since 1946. The first of these chemicals to receive widespread recognition was isopropyl *N*-phenyl carbamate (IPC) and more recently isopropyl *N*-(3-chlorophenyl) carbamate (CIPC) has been intensively studied as a selective herbicide in cotton, alfalfa, and many vegetable crops. Both compounds have also been tested rather extensively in other plant-growth regulatory applications, such as sprout inhibition and fruit thinning, where they have shown considerable promise. Other carbamates, closely related structurally to isopropyl *N*-phenyl carbamate and isopropyl *N*-(3-chlorophenyl) carbamate also have been reported to have plant-growth regulatory activity (*5, 6, 8, 11, 13*).

During the past few years a large number of carbamates and other chemically related compounds have been synthesized and evaluated for plant-growth regulatory activity by the Research Laboratory of the U. S. Industrial Chemicals Co., and from approximately 50 compounds prepared in the initial phase of this program there were chosen, after primary and secondary greenhouse evaluations and preliminary field tests, three compounds believed worthy of more extensive field study. This paper presents various performance data on these three compounds: isopropyl *N*-(3-methylphenyl) carbamate, isopropyl *N*-(2-methoxy-5-chlorophenyl) carbamate, and *sec*-butyl *N*-(3-chlorophenyl) carbamate, in comparison to isopropyl *N*-(3-chlorophenyl) carbamate. which they closely resemble structurally and from the standpoint of activity. In addition to determining the relative activities of these compounds, it was also the purpose of this study to learn something of the influence of soil types on the effectiveness of the chemicals both initially and for their period of residual persistence.

Review of Literature

Shaw and Lovvorn (*13*) have reviewed the significant developments of selective herbicides over the past 10 years. Within the class of substituted *N*-phenyl carbamates they have noted that isopropyl *N*-(3-methylphenyl) carbamate and isopropyl *N*-(2-methyl-5-chlorophenyl) carbamate might possess sufficient activity for development in the future. Shaw and Swanson (*14*) noted that isopropyl *N*-(2-methoxy-5-chlorophenyl) carbamate was rather unusual, in that it inhibited the chlorophyll formation in several weed species without having pronounced effect on either cotton or soybeans. By contrast *sec*-butyl *N*-(3-chlorophenyl) carbamate and isopropyl *N* - (3 - methylphenyl) carbamate, while exerting no particular influence on chlorophyll formation, did exhibit marked selectivity in that they controlled the grasses and certain broadleaved weeds without causing serious injury to cotton or soybeans.

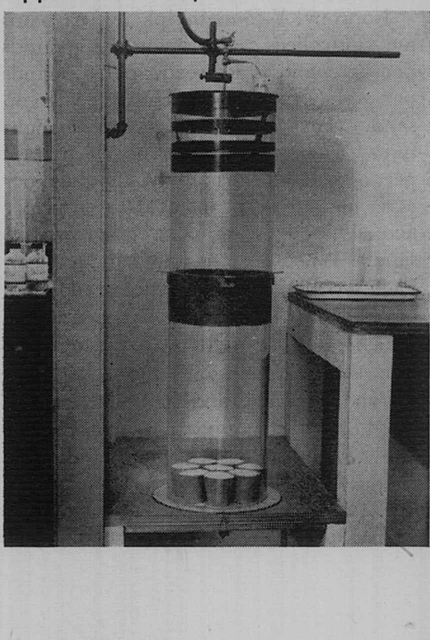
The factors that influence the effectiveness of herbicides are many, but perhaps one of the most important is the type of soil on which treatments are made. Because it is difficult to find several well-defined soil types within the limits of the average field experiment, there is a paucity of specific data on this point. As evidence that the problem is recognized, one need only refer to the recommendations or suggestions published by the state experiment stations of Maine, Massachusetts, New Jersey, and North Carolina for the pre-emergent use of 2,4-D on corn in 1949. Without exception, the amount of chemical suggested or recommended for use on sandy soils was less than that for the loam. Fuelleman (*7*), in summarizing results obtained by several midwestern workers, concluded that successful pre-emergent treatments were particularly dependent on soil type and soil moisture at time of treatment. Roland (*12*) noted, in flower pot experiments, that the germination of wild oats planted in sand was inhibited by 0.5 kg. per hectare of isopropyl *N*-phenyl carbamate while it required 6 kg. per hectare to produce the same result when they were planted in a clay soil. Burt and Willard (*3*) noted that isopropyl *N*-(3-chlorophenyl) carbamate when applied at a rate of

3 pounds per acre to soil low in organic content killed oats and alfalfa, yet did little damage to these plants when they were grown on a soil high in organic matter. Blouch and Fults (*2*) suspected that soil type influenced herbicidal activity, when they were unable to duplicate results with sodium trichloroacetate and isopropyl *N*-(3-chlorophenyl) carbamate in field plots on onions. When the soils representing each area were brought into the greenhouse and the test was repeated in a parallel series, a direct correlation was found between herbicidal activity and soil type. It was shown that the selective action against grasses was far less on sandy and clay soils than on the highly organic loams.

The residual activity of many of the substituted *N*-phenyl carbamates appears to be a function of volatility, which in turn depends on temperature. Anderson, Linder, and Mitchell (*1*) have shown that the volatility of several herbicides becomes appreciable after temperatures reach 85°F. Danielson and France (*4*) have suggested that isopropyl *N*-(3-chlorophenyl) carbamate be used for pre-emergent weed control on many of the salad greens crops during the summer months at a rate of 2 pounds per acre and during the winter months at a reduced rate of 1 pound per acre. These suggestions are based on data showing that the residual period of effectiveness of isopropyl *N*-(3-chlorophenyl) carbamate is much longer at lower temperatures, and consequently there is greater opportunity for crop injury.

Linder (*9*) demonstrated by bioassay that applications of isopropyl *N*-(3-chlorophenyl) carbamate remained in the surface 3-mm. layer of soil. When water was applied, some of the chemical percolated into the soil, this penetration being greater on sandy than on loam soils. The activity of the herbicide was depressed considerably over the period of a month, particularly that fraction in the top 3-mm. layer. Since the experiments were conducted at 80°F., this reduction in activity could have been due to volatility as well as percolation of the chemical to greater soil depths.

Figure 1. Spraying equipment for application of experimental herbicides



Logan, Odell, and Freed (*10*) working with radioactive isopropyl *N*-phenyl carbamate found that the bulk of the material remained in the upper 1 inch of soil even when leached with 1 inch of water. Following 2 inches of simulated rainfall, activity was detected in the fourth inch of soil, but later the chemical appeared to migrate back toward the surface. Smith and Ennis (*15*) demonstrated that isopropyl *N*-(3-chlorophenyl) carbamate was more resistant to leaching action following watering than was 2,4-D. They also noted that leaching action was more pronounced on sandy loam than on clay loam.

Materials and Methods

Ethanolic solutions of isopropyl *N*-(3-methylphenyl) carbamate, isopropyl *N*-(2-methoxy-5-chlorophenyl) carbamate, and *sec*-butyl *N*-(3-chlorophenyl) carbamate, together with the standard isopropyl *N*-(3-chlorophenyl) carbamate were prepared. These were introduced into the top of a glass spray tower 34 inches high and 8.5 inches in diameter by means of a DeVilbiss atomizing spray gun operated at 10 pounds per square inch (Figure 1). The amount of actual chemical applied per unit of area (per acre) was estimated by predetermining the deposit on a metal plate resulting from application of a known volume of the test chemical.

Seeds of the crops or weeds being studied were planted in individual flower pots (2.5-inch Bird Neponset), which were placed in the bottom of the spray tower and retained for 1 minute following the actual spraying operation. Following treatment they were removed to the greenhouse, where they were held for the remainder of the experiment. Temperatures in the greenhouse averaged 80°F., ranging from a minimum of 70°F. to a maximum of 95°F. When sunlight was intense, a muslin curtain was used to shade the treatments. All plants were surface-irrigated as needed, but in general those employing sand as the planting medium required more frequent watering than did those employing loam.

The crop and weed species chosen for these studies were Burpee's Stringless Greenpod beans, Coker 100 Wilt Resistant cotton, Black Wilson soybeans, Clinton oats, crabgrass (*Digitaria sanguinalis*), and chickweed (*Stellaria media*). Seeds for the latter two species were collected locally.

Each plant species was treated at sufficient concentrations to provide a series of responses ranging from no or only slight inhibition of growth to complete retardation. In most cases the individual tests extended over 14 days, at the end of which time a numerical, rating was assigned based on the following scale:

No effect	=	0
Slight	=	1 to 3
Moderate	=	4 to 6
Severe	=	7 to 10

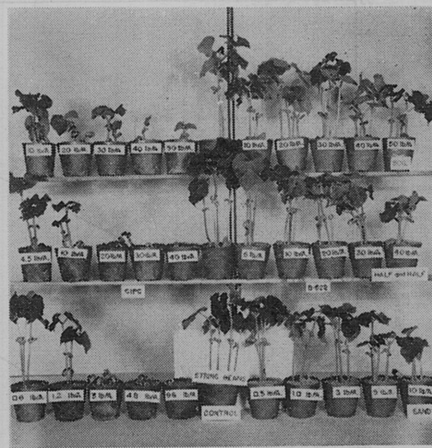


Figure 2. Response of string beans to pre-emergent applications

Burpee's Stringless Greenpod beans planted in sand, soil, or equal mixtures of the two and receiving pre-emergent applications of isopropyl N-(3-chlorophenyl) carbamate and isopropyl N-(2-methoxy-5-chlorophenyl) carbamate

Each concentration was represented by quadruplicate tests and the average activity of these tests was used in plotting the growth-inhibition curves.

As the work developed it was apparent that no one symptom could be used as a criterion by means of which all chemicals could be evaluated against all plant species. In general, a 75% height reduction (compared to untreated) in the test plant was given a "severe" rating, a 50% reduction a "moderate" rating, and a 25% reduction a "slight" rating. If a test plant showed moderate reduction in height but exhibited pronounced chlorotic symptoms, it received a rating of severe, on the assumption that it could not survive for long under those conditions. All tests reported in this study were scored by the same individual. Figure 2 shows one replicate of a representative test of isopropyl *N*-(3-chlorophenyl) carbamate and isopropyl *N*-(2-methoxy-5-chlorophenyl) carbamate (B-522) (III) on beans.

Residual Studies

In conducting tests of residual activity several factors were considered, foremost of which was to have the study conform as nearly as possible to field conditions. Two groups of Neponset flower pots were filled with sand and loam, respectively. These were surface-treated with the experimental chemicals, in two concentrations, and were then placed in the greenhouse to await planting as the program dictated. Two species of test

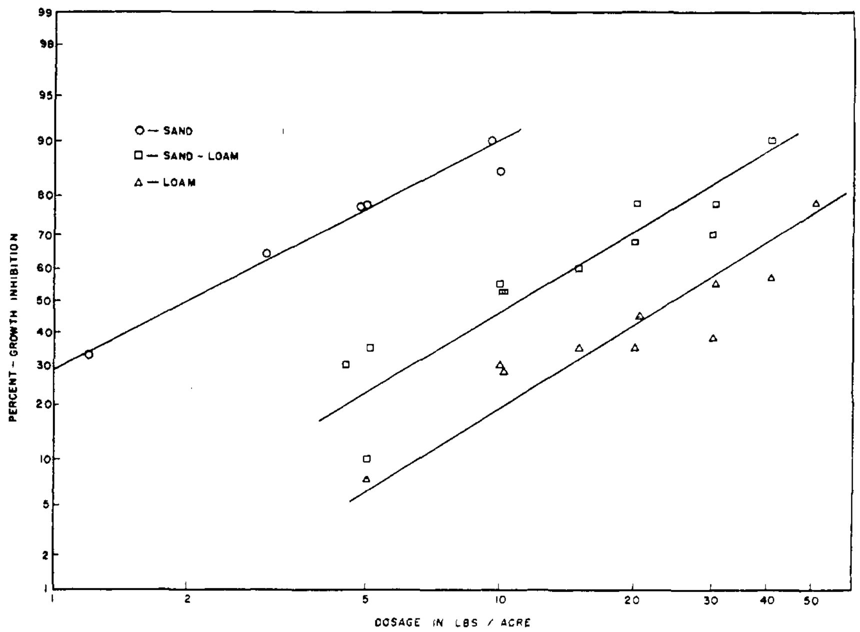


Figure 3. Growth-inhibition regression lines

Effect of isopropyl N-(3-chlorophenyl) carbamate applied as a pre-emergent treatment to Burpee's Stringless Greenpod beans planted in sand, loam, or equal mixtures of the two

plants—string beans and crabgrass—were employed on each soil type and the seeds were planted at weekly intervals for 8 weeks or until results showed the chemical to have no apparent influence on growth. The string beans were planted by punching small holes in the soil and then inserting the seed. Crabgrass was sprinkled on the treated soil, then covered with a thin layer of untreated sand or soil. Both procedures presented some shortcomings, in that the former disturbed the chemical deposit and the latter shielded it from the direct sunlight. All treatments were duplicated and an average of the two was used in the final tabulation. Individual pots were watered as needed, starting at the time that they were transferred to the greenhouse after treatment.

Fresh treatments at the rates employed in the residue tests were included for comparison each week. The two rates of application employed for each chemical on each plant species on each soil type were selected so that one would produce light to moderate growth inhibition and the second severe to complete growth inhibition.

These experimental chemicals have been prepared as emulsifiable concentrates and made available to numerous cooperators for field tests. These were identified as follows: isopropyl *N*-(3-methylphenyl) carbamate (T-516), *sec*-butyl *N*-(3-chlorophenyl) carbamate (T-517), and isopropyl *N*-(2-methoxy-5-chlorophenyl) carbamate (T-518).

Results

Mortalities resulting from application of insecticides or fungicides are often expressed as the concentration or dosage of chemical required to kill or inhibit the growth of 50% of the test organisms (LD_{50}). This figure was obtained in the present study by plotting probits of growth inhibition (in per cent) against logarithms of dosage (in pounds per acre) and then fitting a straight line to these points. While the authors do not know that this procedure has previously been used to evaluate herbicides, preliminary data indicated that the method would be applicable. Because there is interest in the threshold of injury to crop plants as well as the dosage required for a high degree of control of weed species, the LD_{10} and LD_{90} values also have been included in this study. An LD_{10} value represents only a slight change in the growth habits of the plant. In many cases, involving carbamate herbicides, both in the greenhouse and in the field, injuries of this magnitude, especially on the more tolerant broad-leaved species, are outgrown well before maturity. For purposes of direct comparison, the LD_{50} value is undoubtedly the more accurate, since it represents the most sensitive point in the dosage-mortality curve. Typical curves for different types of soil are shown in Figure 3.

The data obtained by applying pre-emergent sprays of isopropyl *N*-(3-methylphenyl) carbamate, *sec*-butyl *N*-(3-chlorophenyl) carbamate, isopropyl *N*-(2-methoxy-5-chlorophenyl) carbamate, and the standard isopropyl *N*-(3-chlorophenyl) carbamate to six plant species grown on three types of soil are summarized in Table I.

While it does not follow that these same results would be obtained under field conditions, certain obvious trends might help in interpretation of field results. First, with one exception (chickweed) it required considerably more chemical to produce a given growth effect when the plants were grown on loam rather than on straight sand. The differences in amounts of material required appear to be greater for the deep-seeded plants.

For example, it required 20 pounds of isopropyl *N*-(3-chlorophenyl) carbamate per acre when cotton was grown on sand to produce a 50% growth inhibition, as compared to 44 pounds per acre when grown on loam. Crab-grass required 0.4 pound per acre on sand, as compared to 0.6 pound on loam. Thus in the first case there was over a 100% increase in the amount of material required for an LD_{50} and in the latter case a 50% increase. These results may help to explain the apparent greater selectivity of herbicides when applied to soils high in organic matter.

Secondly, the results imply that the three experimental chemicals provided good specificity and so all possessed one of the inherent characteristics of a selective crop herbicide. The standard, isopropyl *N*-(3-chlorophenyl) carbamate, produced a severe effect (LD_{90}) on chickweed and crabgrass at 2.6 and 1.5 pounds per acre, respectively, when grown on sand, and 3.4 and 2.3 pounds per acre when grown on loam. If the LD_{10} value is tentatively considered as the threshold of injury to crops, the same chemical on cotton might show some injury at 2 pounds per acre when treatments were on sand, but on loam the dosage could increase to 16 pounds per acre before slight injury would be expected. With soybeans grown on sand, some injury was noted at 0.2 pound per acre and on loam at 5 pounds per acre. When string beans were grown on sand, some injury was noted at 0.7 pound per acre and on loam at 6.5 pounds per acre. Thus, while there was a margin of safety for isopropyl *N*-(3-chlorophenyl) carbamate between control of weeds and injury to cotton, soybeans, and string beans grown on loam soils, this margin was considerably less when the same crop plants were grown on sand.

Isopropyl *N*-(3-methylphenyl) carbamate controlled crabgrass at 5.6 pounds per acre and chickweed at 9.4 pounds per acre (LD_{90}) when each was grown on sand. The same chemical caused slight injury (LD_{10}) to cotton at 20 pounds per acre, soybeans at 1.1 pounds per acre, and string beans at 0.9 pound per acre when these crops were grown on sand. When the tests were conducted on loam, crabgrass and chickweed were controlled with 6.3 and 7.4 pounds of the chemical, respectively. By comparison, the threshold of injury (LD_{10}) to cotton, soybeans, and string beans was 13, 4.8, and 4 pounds per acre, respectively. On the basis of these results, the chemical could be used most safely on cotton, while applications to soybeans and string beans, particularly if grown on sand, might result in temporary crop injury.

sec-Butyl *N*-(3-chlorophenyl) carbamate controlled crabgrass and chickweed (LD_{90}) grown on sand at 9.3 and 5.6 pounds per acre and at 6.2 and 6 pounds per acre when grown on loam. The threshold of injury (LD_{10}) to crops in the same series was 2.2, 0.2, and 0.3 pound per acre for cotton, soybeans, and string beans grown on sand as compared to 15, 3.8, and 8.8 pounds per acre when grown on loam. These results suggest that *sec*-butyl *N*-(3-chlorophenyl) carbamate could be used with safety on cotton and string beans, especially when they were grown on soils high in organic matter content.

Isopropyl *N*-(2-methoxy-5-chlorophenyl) carbamate controlled crabgrass and chickweed, grown on sand, at 9.3 and 5.6 pounds per acre. When the same weeds were grown on loam it required 13 and 6.4 pounds of the chemical to effect the same degree of growth inhibition. In the same series cotton, soybeans, and string beans, grown on sand, showed some growth retardation at 21, 2.6, and 2.8 pounds per acre, while on loam these values were 41, 26, and 22 pounds, respectively. Thus this chemical showed a good margin of safety for cotton grown on sand and for all three crops grown on loam.

Comparisons of these three chemicals with isopropyl *N*-(3-chlorophenyl) carbamate showed that none had an equivalent over-all activity, although each may show greater selectivity on crops other than those investigated. Of the experimental chemicals in these tests, isopropyl *N*-(3-methylphenyl) carbamate has shown the greatest general activity in most cases, *sec*-butyl *N*-(3-chlorophenyl) carbamate was only slightly less active, while isopropyl *N*-(2-methoxy-5-chlorophenyl) carbamate was appreciably less active. One important exception noted for the above order was in activity against crabgrass, where the *sec*-butyl *N*-(3-chlorophenyl) carbamate was uniformly more effective than isopropyl *N*-(3-methylphenyl) carbamate. As the threshold injury rates of these two chemicals to cotton are approximately the same, the increased effectiveness of *sec*-butyl *N*-(3-chlorophenyl) carbamate against crabgrass, one of the most common weed pests in the cotton belt, would encourage its development for weed control in cotton. Although isopropyl *N* - (2 - methoxy - 5 - chlorophenyl) carbamate was in nearly all instances the least active of the three experimental compounds, its selectivity was pronounced and in most cases it was superior to the others in this respect.

Residue Studies

The results obtained on the residual effectiveness of these herbicides are summarized in Table II. Because, for the most part, the tests were designed to give results in the growth response range of each chemical for each plant species, direct comparisons of data are difficult. On the basis of the results obtained, all chemicals demonstrated residual effectiveness periods varying from 1 to 8 weeks, depending primarily on the dosage of the chemical applied. In general, the residual effectiveness against string beans was greater than against crabgrass and it was greater when these plants were growing in loam than in sand. Crabgrass is a shallow-seeded plant requiring much less chemical to produce a given per cent of growth retardation than does the string bean. In the case of plant species that require a relatively small amount of chemical to effect a given response, volatilization will play a more important role in reducing residual life than would be true if large amounts of the chemical were required. Thus a surface treated with 10 pounds per acre might lose 1 pound per week through volatility, affording some residual activity up to 10 weeks. If, under the same conditions, only 1 pound per acre was applied, the chemical would have lost most of its activity in the first week. A certain amount of the deposit will be leached into the soil by surface irrigation. All three factors would contribute to a more rapid loss in residual activity of these treatments on crabgrass.

With string beans, a more deeply seeded plant requiring larger amounts of all of the chemicals to obtain a definite growth response, volatility was less pronounced and any leaching action brought the chemical into more intimate contact with the seed. It is not surprising then that the residual activity for treatments on string beans was somewhat greater.

Conclusions

Three carbamic acid esters were applied as pre-emergent herbicides to six species of plants grown on three types of soil: isopropyl *N*-(3-methylphenyl) carbamate, *sec*-butyl *N*-(3-chlorophenyl) carbamate, and isopropyl *N*-(2-methoxy-5-chlorophenyl) carbamate, all compared to a standard, isopropyl *N*-(3-chlorophenyl) carbamate (CIPC). Results were reported as the amount of chemical, in pounds per acre, necessary to produce a 10, 50, and 90% growth inhibition. To interpret the results in terms of a selective herbicide, it was assumed that 90% growth inhibition of the weed species represented commercial control, while a 10% growth inhibition of crop plants represented a threshold of injury.

In most cases per cent of growth

Table I. Dosages of Carbamic Acid Esters Required to Produce Growth Inhibition

(Pounds per acre of esters required to produce 10, 50, and 90% growth inhibition of several plant species on three soil types)

Chemical	String Beans			Cotton			Crabgrass			Soybeans			Oats			Chickweed		
	LD_{10}	LD_{50}	LD_{90}	LD_{10}	LD_{50}	LD_{90}	LD_{10}	LD_{50}	LD_{90}	LD_{10}	LD_{50}	LD_{90}	LD_{10}	LD_{50}	LD_{90}	LD_{10}	LD_{50}	LD_{90}
Sand																		
I	0.9	3.6	14	5.0	20	76	0.6	1.9	5.6	1.1	4.6	20	0.3	0.7	1.8	0.2	1.3	9.4
II	0.3	2.3	18	2.2	20	100+	0.1	0.5	2.5	0.2	3.2	70	0.2	1.3	7.4	0.3	1.0	3.0
III	2.8	17	100+	21	66	100+	0.9	2.9	9.3	2.6	11	100+	2.5	10	36	0.7	2.0	5.6
CIPC	0.7	2	10	2.0	20	100+	0.1	0.4	1.5	0.2	1.8	21	<0.1	0.2	0.7	<0.1	0.3	2.6
Sand and Loam (Equal Parts)																		
I	3.2	9.6	29	7.6	30	100+	0.7	2	5.2	3.8	12	38	0.3	1.1	4.4	0.3	1.5	7.6
II	3.6	29	100+	9	50	100+	0.4	1.6	6.7	3.2	20	100+	0.8	3.7	17	0.5	1.6	5.0
III	5.8	46	100+	23	94	100+	0.9	3.2	12	5.2	32	100+	4.1	16.0	64	1.0	2.6	6.6
CIPC	2.8	11	44	8	40	100+	0.1	0.4	1.4	1.6	12	91	0.2	0.7	2.9	<0.1	0.5	8.0
Loam																		
I	4	14	48	13	37	100	1.1	2.7	6.3	4.8	17	63	0.8	3.0	12	0.2	1.3	7.4
II	8.8	46	100+	15	80	100+	0.4	1.6	6.2	3.8	22	100+	1.4	7.0	34	0.4	1.5	6.0
III	22	64	100+	41	100+	100+	1.4	4.2	13.0	26	63	100+	8.8	24	69	1.2	2.8	6.4
CIPC	6.5	25	92	16	44	100+	0.1	0.6	2.3	5	20	84	0.2	1.0	4.2	<0.1	1.0	3.4

I. Isopropyl *N*-(3-methylphenyl) carbamate
II. *sec*-Butyl *N*-(3-chlorophenyl) carbamate
III. Isopropyl *N*-(2-methoxy-5-chlorophenyl) carbamate
CIPC. Isopropyl *N*-(3-chlorophenyl) carbamate

inhibition was correlated with soil type; it required much more of the chemical to obtain a 50% growth inhibition when the plants were grown on loam than on sand.

All of the experimental chemicals controlled crabgrass and chickweed at reasonably low dosages, although the rates were somewhat in excess of those required by isopropyl *N*-(3-chlorophenyl) carbamate. All chemicals demonstrated a good margin of safety to cotton grown on loam, but when grown on sand this margin was less for all except isopropyl *N*-(2-methoxy-5-chlorophenyl) carbamate.

No one of the experimental herbicides provided a satisfactory margin of safety to string beans and soybeans grown on sand. When loam was employed as the soil type, *sec*-butyl *N*-(3-chlorophenyl) carbamate, isopropyl *N*-(2-methoxy-5-chlorophenyl) carbamate, or isopropyl *N*-(3-chlorophenyl) carbamate caused no serious growth inhibition at rates of application that controlled crabgrass and chickweed. With soybeans grown on loam, only isopropyl *N*-(2-methoxy-5-chlorophenyl) carbamate demonstrated a sufficient margin of safety

Results of experiments on the residual effectiveness of these chemicals indicated that this period could vary from 1 to 8 weeks, depending primarily on the dosage of the chemical applied initially. Soil type, plant species, volatility of test chemical, and percolation through planting medium were all considered as important factors contributing to residual life.

The results of this study emphasize a trend that has been taking place in all phases of agricultural pest control—the application of a specific chemical for a specific problem. In the field of herbicides the problems of specificity and selectivity become even more complex, and it is not difficult to foresee the development of tailor-made chemicals for use on specific crops grown under specific agronomic and climatological conditions.

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Table II. Residual Activity of Three Carbamic Acid Esters and Isopropyl *N*-(3-Chlorophenyl) Carbamate against Two Plant Species Planted on Two Soil Types

Chemical	Test Plant	Rate of Treatment, Lb./Acre	Growth Inhibition, %: Fresh treatment	Residual, Weeks after Treatment: 1	2	3	4	5	6	7	8	Residual Period, Weeks
					Sand							
I	Crabgrass	1.2	31	5	0	0	..	..	..	..	..	1
		4.8	85	40	0	0	..	..	..	..	..	1
I	String beans	2.0	25	20	0	0	0	0	0	..	..	1
		8.0	74	70	15	20	10	0	0	..	..	4
II	Crabgrass	0.3	40	0	0	0	0	..	..	..	..	0
		2.0	80	40	5	0	0	..	..	..	..	2
II	String beans	3.0	62	10	15	0	0	0	0	0	0	2
		20.0	88	90	70	40	5	5	20	0	0	6
III	Crabgrass	2.0	38	5	0	0	0	..	..	..	..	1
		10.0	91	45	10	0	0	..	..	..	..	2
III	String beans	5.0	23	10	15	0	0	0	0	0	0	2
		30.0	58	60	40	30	25	15	10	0	0	6
CIPC	Crabgrass	0.15	10	20	0	0	0	..	..	..	..	1
		0.6	81	10	10	0	0	..	..	..	..	2
CIPC	String beans	3.0	72	35	0	10	0	0	..	..	..	3
		10	83	70	60	35	0	0	..	..	..	3
					Loam							
I	Crabgrass	3.0	53	5	0	0	..	..	..	..	..	1
		8.0	91	50	5	0	..	..	..	..	..	2
	String beans	10.0	54	40	5	0	5	0	0	0	0	4
		50.0	88	80	80	80	60	95	80	30	30	8+
II	Crabgrass	1.0	29	0	0	0	0	0	0	0	0	0
		9.0	91	40	20	30	0	5	0	0	0	5
II	String beans	20.0	49	25	30	0	15	5	20	5	0	7
		80.0	83	90	85	60	90	80	80	80	90	8+
III	Crabgrass	4.0	46	5	0	0	0	0	0	0	0	1
		15.0	91	80	50	15	20	5	0	0	0	5
III	String beans	40.0	40	30	15	10	35	20	20	15	0	7
		80.0	72	60	40	40	35	40	40	30	30	8+
CIPC	Crabgrass	0.6	36	10	5	0	0	..	..	..	..	2
		3.0	94	85	75	0	0	..	..	..	..	3
CIPC	String beans	10.0	71	80	30	40	0	45	0	15	5	8+
		50.0	89	90	90	90	90	90	90	90	80	8+

I. Isopropyl *N*-(3-methylphenyl) carbamate
II. *sec*-Butyl *N*-(3-chlorophenyl) carbamate
III. Isopropyl *N*-(2-methoxy-5-chlorophenyl) carbamate
CIPC. Isopropyl *N*-(3-chlorophenyl) carbamate