Enhanced Phytotoxicity of Bentazon with Organophosphate and Carbamate Insecticides

Author(s): James R. Campbell and Donald Penner

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Enhanced Phytotoxicity of Bentazon with Organophosphate and Carbamate Insecticides[1]

JAMES R. CAMPBELL and DONALD PENNER[2]

Abstract. **The organophosphate insecticides, malathion [*S*-1,2-di(ethoxycarbonyl)ethyl *O,O*-dimethyl phosphorodithioate], parathion (*O,O*-diethyl *O*-4-nitrophenyl phosphorothioate) and diazinon (*O,O*-diethyl *O*-2-isopropyl-6-methylpyrimidin-4-yl phosphorothioate) combined with bentazon [3-isopropyl-1*H*-2,1,3-benzothiadiazin-4(3*H*)-one 2,2-dioxide], caused severe injury to soybean [*Glycine max* (L.) Merr. 'Corsoy'] and navy bean (*Phaseolus vulgaris* L. 'Seafarer'). Postemergence tank-mixture applications of bentazon with organophosphate or carbamate insecticides, or soil-applied organophosphate insecticides prior to bentazon treatments, did not interact with bentazon to injure corn (*Zea mays* L. 'Great Lakes Hybrid 4122'). Technical grade malathion interacted with bentazon to the same extent as formulated malathion. Combination treatments of malathion with bentazon resulted in the same degree of injury whether they were applied as tank mixtures or split applications 48 h apart.**

Additional index words. Glycine max, Phaseolus vulgaris, **malathion, parathion, diazinon.**

INTRODUCTION

One of the management practices that allows for greater economic savings and production efficiency is the simultaneous application of several pesticides as tank mixtures. Of potential interest would be the postemergence application of bentazon herbicide-insecticide combinations. There are, however, numerous reports showing that certain herbicide-insecticide combinations may increase phytotoxicity to the crop (1, 3, 5, 6, 8, 9).

The combination of bentazon with the herbicide, diclofop {2-[4(2,4-dichlorophenoxy)phenoxy] propanoic acid}, is known to interact to increase injury to soybean (11). Often these pesticide interactions are due to a change in uptake or metabolism of the herbicide (4, 10, 12).

The present study evaluates the potential interaction of bentazon with several organophosphate and carbamate insecticides.

MATERIALS AND METHODS

Corsoy soybean, Great Lakes Hybrid No. 4122 corn, and Seafarer navy bean were seeded, five seeds/946-ml wax cup, into greenhouse soil (1:1:1, v/v/v, soil:sand:peat). Seedlings were thinned to three uniform plants/pot 10 days later. Pesticides were applied with a link belt sprayer at 245 kPa pressure with 280 L/ha spray volume. The plants were at the following leaf stage at application: the first trifoliolate leaf of soybean was one-half to fully expanded, the second leaf of the corn plant was emerging from the whorl, and the second trifoliolate leaf of navy bean was fully expanded. Initial experiments with soybean and navy bean were conducted in a greenhouse at 25 ± 5 C without supplemental lighting. Soybean and corn plants in subsequent experiments were grown out-of-doors during August and September.

Commercial formulations of the insecticides, malathion emulsifiable concentrate (EC) at 1.1 kg ai/ha, parathion EC at 0.56 kg ai/ha, diazinon wettable powder (WP) at 2.2 kg ai/ha, carbaryl WP or carbaryl (1-naphthyl methylcarbamate) flowable liquid (FL) at 1.1 kg ai/ha, and carbofuran (2,3-dihydro-2,2-dimethylbenzofuran-7-yl methylcarbamate) FL at 1.1 kg ai/ha, were applied.

Herbicide-insecticide combination treatments were applied as tank mixtures. Because of the similarity of plant response of greenhouse and outdoor-grown plants, the following experiments were conducted under greenhouse conditions.

Commercial granular formulations of terbufos (S-*tert* butylthiomethyl *O,O*-diethyl phosphorodithioate) at 1.1 kg ai/ha, carbofuran at 0.84 kg ai/ha and fonofos (*O*-ethyl-*S*-phenylethylphosphonodithioate) at 1.1 kg ai/ha were incorporated into the top 5 cm of a mixture of sand and soil (1:1, sandy loam:beach sand, v/v). Postemergence treatments of bentazon at 1.7 kg ai/ha were applied to corn at two stages of growth, either as the first leaf or the fourth leaf was emerging from the whorl. To determine whether the active ingredient in an insecticide formulation was interacting with bentazon, formulated malathion[3] and technical grade malathion at 1.1 kg ai/ha were applied with and without bentazon at 1.7 kg ai/ha to soybean plants when the first trifoliolate leaves were expanding. The technical malathion was kept in suspension with water by constant agitation, and application was with a hand-held atomizer. In a split application study, formulated malathion was applied 48 or 3 h before, or 3 or 48 h after, an application of bentazon.

All plants were fertilized with a solution containing 100 ppm (w/v) of N, P_2O_5, and K_2O. All experiments were in a randomized design with four or five replications/experiment. Data presented are the means of at least two experiments.

RESULTS AND DISCUSSION

Postemergence applications of bentazon or any of the insecticides alone did not result in injury to soybean measured as a reduction in soybean fresh weight 14 days after treatment (Table 1). Severe injury resulted from combination treatments of the organophosphate insecticides, malathion, parathion, and diazinon with bentazon. Injury symptoms were visible within 24 h as an interveinal water-soaked appearance, followed by necrosis and leaf abscission within

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[2] Grad. Asst. and Prof., respectively, Dep. Crop and Soil Sci., Pesticide Res. Center, Michigan State Univ., East Lansing, MI 48824.

[3] Malathion 50. Chevron Corp.

Table 1. Effect of insecticides and bentazon on the fresh weight of soybeans, navy beans, and corn 14 days after application.

Insecticide	Rate	Soybean fresh weight[ab]		Navy bean fresh weight[ab]		Corn fresh weight[ab]	
		−Bentazon	+Bentazon	−Bentazon	+Bentazon	−Bentazon	+Bentazon
	(kg/ha)	(% of control)					
Control		100cd	107cd	100c	96c	100bcd	101bcd
Malathion	1.1	109d	42a	98c	48a	89abc	82a
Parathion	0.56	105cd	72b	107c	53a	99abcd	96abcd
Diazinon	2.2	104cd	82b	95c	72b	99abcd	96abcd
Carbaryl	1 1	111d	95c	100c	96c	108d	88abc
Carbofuran	1.1	112d	103cd	103c	92c	105cd	105cd

[a]Means with a crop main heading followed by the same letter are not significantly different at the 5% level as determined by Duncan's multiple range test.

[b]−Bentazon = without bentazon; +Bentazon = with bentazon at 1.7 kg/ha.

a few days. The onset of injury was more rapid on soybeans grown outside than those grown in the greenhouse.

Only the combination of malathion and bentazon resulted in a corn fresh-weight reduction compared to the control (Table 1). This combination treatment was not significantly different from malathion alone, however, and the corn rapidly recovered from the injury.

Navy beans treated with bentazon or any of the insecticides alone were not injured (Table 1). Combination treatments of malathion, parathion, or diazinon with bentazon resulted in large reductions in fresh weight and severe leaf injury. This injury was either a rapid necrosis of the leaf tissue or a chlorosis, which was not restricted to any veinal or interveinal portion of the leaf. The combination treatment of the phosphorothioate- or phosphorodithioate-type insecticides, parathion, diazinon, and malathion, with bentazon resulted in increased injury to soybean and navy bean. The carbamate-type insecticides, carbofuran and carbaryl, when combined with bentazon, did not interact although all have been shown to be esterase inhibitors (7).

The interactions between bentazon and the insecticides were evaluated using Colby's (2) multiplicative model for interactions, and the statistical significance between the expected and actual combination value was calculated as outlined by Hamill and Penner (4). The analysis indicated significant synergistic reduction in plant fresh weight. This synergism was observed to a decreasing extent in the following order: soybean, navy bean, and corn (Table 2).

Soil application of the insecticides, terbufos, carbofuran, or fonofos, followed by a postemergence application of bentazon to corn, did not cause a significant reduction in fresh weight (data not shown). Yellow nutsedge (*Cyperus esculentus* L.) shoots treated with malathion at 1.1 kg/ha and bentazon at 1.1 kg/ha were not injured more severely than yellow nutsedge shoots treated with bentazon alone.

The mixtures of formulated malathion or technical malathion with bentazon resulted in the same degree of injury to soybean (Table 3). This indicated that the synergistic injury caused by bentazon plus malathion resulted from the active ingredient in the malathion formulation. Although bentazon alone caused a significant reduction in fresh weight, the injury resulting from the combination treatment was much more severe.

Split-application treatments of malathion and bentazon

Table 2. Calculations of expected interaction responses using Colby's formula on soybean, navy bean, and corn.

Bentazon[a] plus insecticide	Rate	Soybean fresh weight		Navy bean fresh weight		Corn fresh weight	
		Expected	Actual[b]	Expected	Actual[b]	Expected	Actual[b]
	(kg/ha)	(% of control)					
Malathion	1.1	103	38**	106	41**	79	80
Parathion	0.56	102	52**	123	52**	90	91
Diazinon	2.2	115	61**	99	80	97	97
Carbaryl	1.1	109	79**	103	100	101	81*
Carbofuran	1.1	91	86	115	84*	104	104

[a]Bentazon rate was 1.7 kg/ha.

[b]Means followed by double asterisk (**) are significant at the 1% level; means followed by (*) are significantly different at the 5% level from the calculated expected mean.

Table 3. Effect of malathion formulation on the interaction with bentazon on soybeans 7 days after application.

Treatment	Rate	Soybean fresh weight[a]
	(kg/ha)	(% of control)
Untreated		100d
Bentazon	1.7	74b
Malathion-formulated[b]	1.1	79b
Malathion-technical	1.1	88c
Bentazon + malathion-formulated	1.7 + 1.1	26a
Bentazon + malathion-technical	1.7 + 1.1	31a

[a]Numbers followed by the same letter are not significantly different at the 5% level as determined by Duncan's multiple range test.

[b]Malathion formulation was a 50% emulsifiable concentrate.

Table 4. The effect of split applications of malathion and bentazon on the fresh weight of greenhouse-grown soybeans 7 days after application.

Treatment	Rate	Soybean fresh weight[a]
	(kg/ha)	(% of control)
Untreated		100cd
Bentazon	1.7	92c
Malathion	1.1	103d
Malathion 48 h before bentazon	1.1 + 1.7	49b
Malathion 3 h before bentazon	1.1 + 1.7	37a
Malathion-bentazon tank mix	1.1 + 1.7	37a
Malathion 3 h after bentazon	1.1 + 1.7	40ab
Malathion 48 h after bentazon	1.1 + 1.7	42ab

[a]Means followed by the same letter are not significantly different at the 5% level as determined by Duncan's multiple range test.

resulted in severe reductions in soybean fresh weight (Table 4). This response occurred when the malathion was applied up to 48 h before or after bentazon. The injury from split applications did not differ, or differed only slightly, from the injury caused by a malathion-bentazon tank mixture. These results indicated that the interaction between the chemicals themselves was not significant, but that any interactions had to be on or within the leaf itself.

Postemergence combinations of bentazon with organophosphate insecticides were injurious to soybean and navy bean. It is uncertain whether the injury was due to the bentazon or the insecticide, or whether other organophosphate insecticides would induce the same effect with bentazon. The carbamate insecticides, carbaryl and carbofuran, were compatible with bentazon in all crops studied. Because the interaction of bentazon with the organophosphates occurred even if applications were separated by 48 h, it seems likely that the insecticides interfered with bentazon metabolism and that the interaction was not a result of a chemical change in the spray mixture. On corn, the combinations of the organophosphate or carbamate insecticides were compatible with postemergence applications of bentazon when the insecticides were applied either as preplant incorporated granules or postemergence sprays.

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