Bentazon에 대한 고추품종간 내성 차이

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Differential Tolerance of Pepper Cultivars to Bentazon

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ABSTRACT

Greenhouse studies were conducted to evaluate the tolerance of 42 pepper cultivars to postemergence applications of bentazon [3-(1-methylethyl)-(1*H*)-2,1,3-benzothiadiazin-4(3*H*)- one 2,2-dioxide]. Cultivars, Jopoong, Jonggahjip, Singsing House, Sweet Green, Kwangbok, and Ilcheon showed relatively tolerant response to bentazon, while cultivars, Dahhong, Early Glory, Korea, Cheongyang, Nostalgia, and Daejanggyeong were susceptible ones to it. At rates over 2.40 kg ai/ha, the tolerant cultivars appeared to be clearly or more tolerant than the susceptible cultivars. For the determination of growth inhibition by bentazon, the concentration required to reduce growth by 50% (GR_{50}) was 2.00 to 2.40 kg ai/ha for susceptible cultivars, and 10.00 to 12.00 kg ai/ha for tolerant cultivars. Moreover, the herbicide rate required to inhibit growth by 50% (I_{50}) was 2.40 kg ai/ha for susceptible cultivars and 9.60 kg ai/ha for tolerant cultivars, respectively. On the I_{50} and GR_{50} estimates of growth, the tolerant cultivars were 5- to 6-fold more tolerant to bentazon than susceptible ones.

Key words : Bentazon, pepper, tolerance, growth

INTRODUCTION

Exploiting existing herbicide tolerance in crop plants and related species through the crop improvement can economically and practically increase weed control solutions. Evaluation of differential cultivar tolerance to herbicides has been variable for numerous crops, including corn,[3,4,10)] pepper,[1,6,17,18)] potato,[5)] rice,[13)] soybean,[2,7,8,9,16)] tomato,[14)] and wheat.[11)] Crop cultivar response to herbicides may be determined by evaluation of various injury symptoms, crop emergence and development, and possible yield reductions.

Several types of herbicides, such as clomazone, fluazifop-P, and oxyfluorfen, have been widely used to control major grasses and broadleaf weeds in pepper.[12,15)] However, the sensitivity of herbi-

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cides of each pepper cultivar appears differential response to herbicide within a crop species. Trials conducted to explore the possibility of using bentazon for weed control in peppers have demonstrated that a variety of hot pepper (*Capsicum chineinse*) was highly tolerant, whereas sweet pepper (*C. annuum*) was susceptible to the herbicide.[1] In addition, evaluation of differential tolerance in peppers has identified high tolerance in two hot pepper cultivars ; Bohemian Chile and Santanka,[6,17] and three U.S. Dept. of Agriculture plant introductions ; PIs 127445, 163187, and 246123.[17] The susceptibility and tolerance of pepper cultivars to bentazon was demonstrated under greenhouse and field conditions in which indicated a high degree of variability in bentazon tolerance.[1,6] Often, injury symptoms observed with greenhouse conditions correlate well with field studies.

Although previously difference in tolerance to bentazon within a plant species has been identified,[1,6,17,18] bentazon tolerant pepper cultivars have not been observed particular pepper cultivars the production in Korea. To assess the variability in bentazon tolerance among cultivars, the objective of this study was to evaluate the tolerance of 42 pepper cultivars to postemergence applications of bentazon under greenhouse conditions.

MATERIALS AND METHODS

Herbicide treatment

Solution of the desired herbicide concentrations were prepared using commercial formulations of bentazon. Nonionic surfactant (X-77) (principal functioning agents-alkylarylpolyoxy-ethlene, glycols, free fatty acids, isopropanol) at 0.25% by volume was included in herbicide treatments.

General greenhouse procedure

Seeds of 42 pepper cultivars were sown in plastic tray (surface area : 27×53 cm^2) containing a potting mixture of soil : vermiculite : peat (2 : 1 : 1 by vol). The trays were then planted and maintained in a greenhouse at 28℃ to 30℃ during the day and night, respectively. Ten days after emergence, seedlings were thinned to one per plot. After the pepper plants reached to a 2- to 3-leaf stage, all herbicide treatments were applied with a CO_2-pressurized backpack hand-held boom sprayer. The sprayer was calibrated to deliver 1,000 L/ha at 300 kPa.

Phytotoxicity was visually evaluated at 10 days after application (DAA) based on a 0 to 100 scale, where 0 = no injury, 30 = moderate foliar chlorosis with small necrotic lesions, 70 = severe necrosis, and 100 = death of plants.[6] Subsequently, plant heights from the soil surface to the last fully expanded leaf were determined. The plants were harvested and shoot fresh weights recorded 10 days after application. The shoots were then oven dried at 80℃ for 48 hr and dry weights measured. Plant height, shoot fresh weight, and dry weight reduction was determined for each of the herbicide-treated plants by converting data to percent of the corresponding control and subtracting from 100%. The study was repeated and the data were combined.

Screening for tolerance to bentazon

A preliminary greenhouse experiment was conducted to determine the herbicide concentration necessary to cause differential responses among 42 pepper cultivars to bentazon. Herbicides were applied at 1.60 and 3.20 kg ai/ha bentazon. Plants were treated one month after germination and harvested 10 days later using the previously described scale. Each treatment was replicated two times and untreated control was provided for comparison. The treatments were arranged in a completely randomized design with three replications.

Growth response of pepper cultivars to bentazon

For the determination of growth inhibition by bentazon, this experiment was conducted to compare the different concentrations of herbicide to the pepper, presenting in the representatives of tolerant- and susceptible-cultivars. The seeds of two tolerant cultivars, Jopoong and Jonggahjip, and two susceptible cultivars, Nostalgia and Daejanggyeong from the screening experiment were planted using the above mentioned procedure. The plants were treated with bentazon at 0, 0.80, 1.60, 3.20, 6.40, and 12.80 kg ai/ha. Herbicide rates required to inhibit growth by 50% (I_{50} value) for visual injury or to reduce growth by 50% (GR_{50} value) for plant height, shoot fresh weight, and dry weight were estimated. The experiment was completely randomized with four replications.

RESULTS AND DISCUSSION

Screening for tolerance to bentazon

Under greenhouse screening tests, a preliminary studies were conducted to determine the herbicide concentration necessary to cause differential response among cultivars. The plants were categorized as herbicide tolerant or susceptible based on the range and distribution of visual injury, plant height, shoot fresh biomass, and dry weight reduction data. Evaluation of 42 pepper cultivars as affected by herbicide treatment at 1.60 and 3.20 kg ai/ha bentazon were shown in Table 1. There was differential cultivar responses of pepper, a high degree of variability in herbicide tolerance, to bentazon herbicide. The results showed that 6 cultivars represented the group of tolerance such as Jopoong, Jonggahjip, Singsing House, Sweet Green, Kwangbok, and Ilcheon. whereas 6 cultivars represented susceptible group such as Dahhong, Early Glory, Korea, Cheongyang, Nostalgia, and Daejanggyeong.

Based on visual injury, plant height, fresh weight, and dry weight, the difference in response of cultivars to herbicide was observed (Table 1). The response to the herbicide treatment depended on the cultivars treated, showing symptoms after 3 to 5 days of the application followed by foliar desiccation and necrosis. When the tolerant plants

Table 1. Visual injury, plant height, fresh weight, and dry weight of pepper cultivars tolerant and susceptible to 1.60 and 3.20 kg ai/ha bentazon. Plants were treated[a] one month after germination and harvested 10 days later.

Pepper cultivar	Rate (kg/ha)	Phytotoxicity[b]		Plant height		Fresh weight		Dry weight	
		1.60	3.20	1.60	3.20	1.60	3.20	1.60	3.20
				% of control					
Ilcheon		20	30	87.96	75.08	85.11	73.48	85.16	75.53
Singsing House		20	30	82.56	76.43	80.69	75.52	82.12	75.64
Sweet Green		20	30	80.34	77.78	87.69	74.53	82.69	77.19
Jonggahjip		20	30	82.88	75.73	82.32	76.06	86.31	75.12
Jopoong		20	30	80.04	76.07	86.07	75.51	80.10	72.91
Kwangbok		20	30	88.41	78.79	82.52	72.22	83.71	74.83
Korea		45	70	59.56	45.87	64.33	42.68	55.59	30.94
Daejanggyeong		45	70	55.80	35.62	67.94	40.31	52.94	36.18
Cheongyang		45	70	56.06	45.76	63.45	46.06	56.13	38.72
Dahhong		45	70	66.91	43.24	64.64	38.43	53.83	33.99
Early Glory		45	70	63.29	40.13	64.61	42.62	59.67	36.43
Nostalgia		45	70	56.31	44.02	63.96	32.70	53.56	30.78

a/ Nonionic surfactant (X-77) was included in all treatments at 0.25% by vol.
b/ Visual rating, where 0 indicated no visible effect and 100 indicated complete death of plants.

were treated with bentazon at 1.60 kg ai/ha, they showed 20% inhibition in plant growth and had plant heights, fresh weights, and dry weights equal to or greater than 80% of the untreated control. On the other hand, the susceptible plants showed 45% inhibition in plant growth and had plant heights, fresh weights, and dry weights greater than 50% of the untreated control. In addition, when the tolerant plants were treated at 3.20 kg ai/ha bentazon, they showed 30% inhibition in plant growth and had plant heights, fresh weights, and dry weights greater than 70% of the untreated control. The susceptible plants, however, showed 70% inhibition in plant growth and had plant heights, fresh weights, and dry weights equal to or greater than 30% of the untreated control. These data suggest that the levels of tolerance to bentazon differed clearly among the test cultivars.

Baltazar *et al.*,[1] and Harrison and Fery[6] reported the similar result on the evaluating responses of pepper cultivars to bentazon. These indicated that phytotoxicity was increased and shoot fresh weight was decreased as bentazon concentrations increased. In general, bentazon is known to inhibit photosynthesis by blocking Photosystem II of the electron transport system in treated plants.[15] It is assumed that the effect of bentazon agrees with the influences of the herbicide on phytotoxicity, plant height, fresh weight, and dry weight of tolerant and susceptible cultivars.

Growth response of pepper cultivars to bentazon

For the determination of growth inhibition by various concentrations of herbicide, the four pepper cultivars used in screening experiments were again evaluated in this experiment. This experiment was conducted to compare responses of cultivars to bentazon between bentazon-tolerant cultivars, Jong-gahjip and Jopoong and-susceptible cultivars, Daejang-gyeong and Nostalgia presenting in the representatives of the herbicide-response cultivars. The growth response of four pepper cultivars to bentazon, as mentioned earlier, was determined at different concentration at 0, 0.80, 1.60, 3.20, 6.40, and 12.80 kg ai/ha bentazon. Based on visual injury, plant height, fresh weight, and dry weight, suggesting that growth of plants were inhibited according to the concentration of herbicide (Fig. 1, 2, 3, and 4). There was greater difference in response between tolerant and susceptible cultivars.

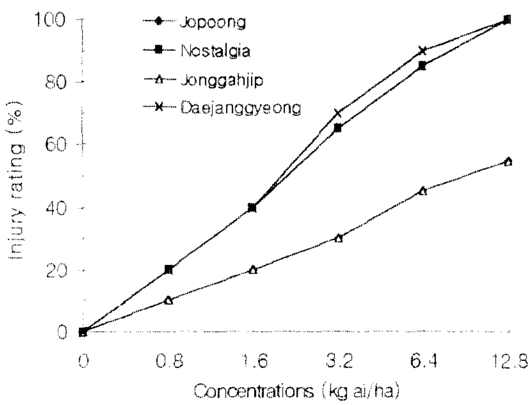

Fig. 1. Effect of bentazon on injury of tolerant (Jopoong and Jonggahjip) and susceptible (Nostalgia and Daejanggyeong) cultivars determined 10 days after herbicide application.

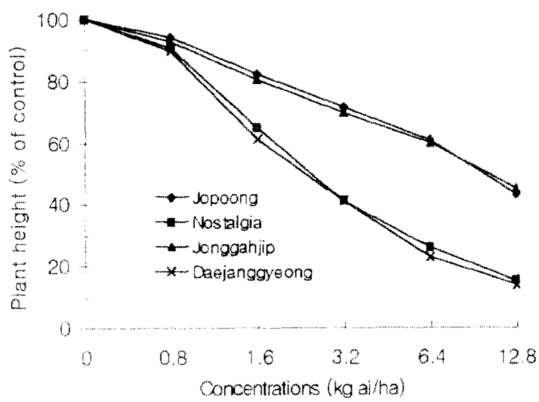

Fig. 2. Effect of bentazon on plant height of tolerant (Jopoong and Jong-gahjip) and susceptible (Nostalgia and Daejanggyeong) cultivars determined 10 days after herbicide application.

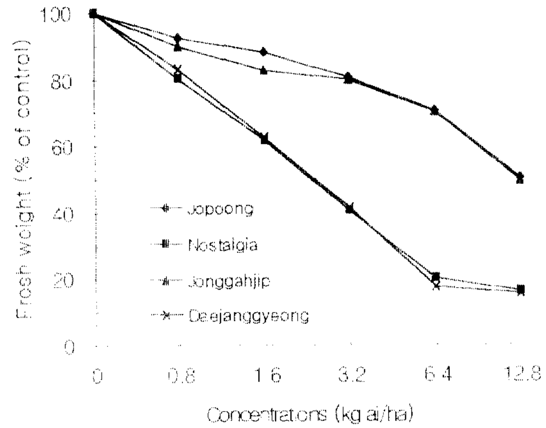

Fig. 3. Effect of bentazon on shoot fresh biomass of tolerant (Jopoong and Jonggahjip) and susceptible (Nostalgia and Daejanggyeong) cultivars determined 10 days after herbicide application.

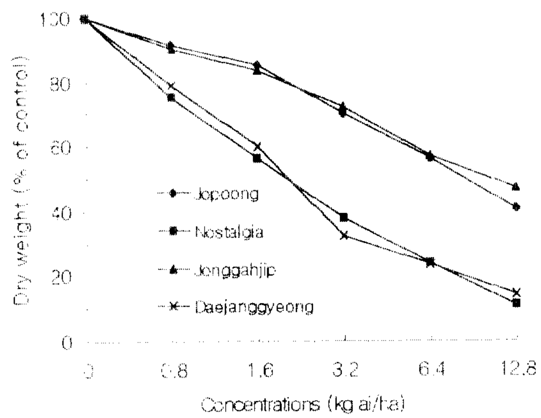

Fig. 4. Effect of bentazon on dry weight of tolerant (Jopoong and Jong-gahjip) and susceptible (Nostalgia and Daejanggyeong) cultivars determined 10 days after herbicide application.

At rates over 2.40 kg ai/ha, the tolerant cultivars appeared to be clearly or more tolerant than the susceptible ones. The susceptible cultivars were injured moderately (injury ratings greater than 30 %) by bentazon at 1.20 kg ai/ha, while the tolerant cultivars were injured moderately by bentazon at 3.20 kg ai/ha. This injury was expressed as localized foliar lesions with little effect on meristematic tissue or new growth. Furthermore, the susceptible cultivars were injured severely (injury ratings greater than 70%) by bentazon at 3.20 kg ai/ha and higher, while the tolerant cultivars were injured severely by bentazon at rates over 12.80 kg ai/ha. This injury was expressed as severe foliar injury with subsequent deformity of new growth and greatly reduced shoot fresh biomass. These data suggest that two tolerant cultivars, designated as tolerant such as Jonggahjip and Jopoong, showed high tolerance to bentazon. However, the rate of decrease in plant height, fresh weight, and dry weight was greater with susceptible ones such as Daejanggyeong and Nostalgia.

Baltazar et al.[1] reported that the tolerant cultivar, Bohemian Chile, tolerated foliar application of up to 6.70 kg ai/ha bentazon. Harrison and Fery[6] have also reported that yields or shoot fresh weights of two tolerant cultivars, Bohemian Chile and Santanka, were not reduced by up to 9.00 kg ai/ha bentazon. Especially, Santanka, the tolerant cultivar in the studies of Harrison and Fery[6] showed a high level of bentazon tolerance. The results of this study confirmed the findings of the previous paper in which pepper cultivars varied greatly in bentazon tolerance and that selected cultivars tolerate high bentazon rates.[1,6,17,18] As the concentration of bentazon increased, there was greater difference in herbicide phytotoxicity and shoot fresh weight between tolerant and susceptible cultivars. This indicates that the differential response of pepper cultivars may be correlated with tolerance to the herbicide.

Since a considerable difference in tolerance to bentazon exists between tolerant and susceptible peppers, herbicide rates required to inhibit growth by 50% (I_{50}) for visual injury or to reduce growth by 50% (GR_{50}) for plant height, shoot fresh weight, and dry weight was determined (Table 2). The I_{50} estimates was 9.60 kg ai/ha for tolerant cultivars and 2.40 kg ai/ha for susceptible ones (Fig. 1). In addition, the GR_{50} estimates was 10.00 to 12.00 kg ai/ha for tolerant cultivars, and

Table 2. GR_{50} and I_{50} evaluates for the response of 4 pepper cultivars to bentazon.

Pepper cultivar	GR_{50}	I_{50}
	············ kg ai/ha ············	
Jonggahjip	12.00 ± 0.8[a/]	9.60 ± 0.1
Jopoong	10.00 ± 0.6	9.60 ± 0.2
Daejanggyeong	2.40 ± 0.1	2.40 ± 0.1
Nostalgia	2.00 ± 0.4	2.40 ± 0.1

a/ Presented data are mean estimates ± the standard error of the mean.

2.00 to 2.40 kg ai/ha for susceptible ones, respectively (Fig. 2, 3, and 4). On the I_{50} and GR_{50} estimates of growth, bentazon tolerance varied considerably within pepper cultivars, suggested that the I_{50} values generally corresponded with the GR_{50} values. This indicated that the tolerant cultivars were 5- to 6-fold more tolerant to bentazon than susceptible ones.

A similar trend was observed in phytotoxicity and shoot fresh weight of pepper cultivar treated with bentazon. Harrison and Fery observed a good correlation between I_{50} and GR_{50} values.[6] This paper indicated that the GR_{50} estimates ranged from 2.70 to 3.10 kg ai/ha for susceptible cultivars, and 7.20 to 7.70 kg ai/ha for tolerant ones, respectively. The corresponding I_{50} estimates was 2.00 to 2.50 kg ai/ha for susceptible cultivars, and 6.70 to 6.90 kg ai/ha for tolerant ones.

Conceptually, a major advantage in evaluating crop plants tolerant to herbicide is the use of such variants for studying potential mechanisms of herbicide action and/or to facilitate an understanding of a particular plant biological, physiobiological, as well as molecular genetical process. Furthermore, the long-term intention is to confer a trait to a crop plant, exhibit tolerance to useful herbicides, that will improve its agricultural value.

In conclusion, bentazon-tolerant pepper cultivars was selected. Our results showed the tolerant cultivars were 5- to 6-fold more tolerant to bentazon than susceptible ones. These data provide fundamental information of pepper tolerance to bentazon, however, future investigation is needed to study the precise selection mechanism of the tolerant plants and the site of action of bentazon.

적 요

Bentazon에 대한 품종간 내성을 검정하기 위하여 온실에서 42 고추품종을 30일간 재배한 다음 Bentazon을 경엽처리하여 내성품종과 감수성품종을 선발하였다. 조풍, 종가집, 싱싱하우스, 녹광, 광복 및 일천 품종은 비교적 내성을, 대홍, 조광, 고려, 청양, 향촌 및 대장경 품종은 감수성을 나타냈다. 내성품종은 Bentazon 3.4 kg/ha 이상 수준에서도 감수성품종에 비하여 현저한 내성을 보였다. 고추생장을 50% 저해하는 Bentazon 농도(I_{50})는 감수성품종은 2.0 ~ 2.4 kg/ha, 내성품종은 10.0 ~ 12.0 kg/ha이며 또한 50% 생장을 감소시키는 Bentazon 농도(GR_{50})는 감수성품종은 2.4 kg/ha이고 내성품종은 9.6 kg/ha이었다. 따라서 내성품종은 감수성품종보다 5 ~ 6배 내성을 나타내었다.

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