SEEDLING GROWTH TOLERANCE OF CUCURBITS CROPS TO HERBICIDES STOMP AND ACETOCHLOR

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Summary. Several species from the Cucurbitaceae family including muskmelon, watermelon, cucumber, pumpkin, and squash were used to evaluate their tolerance in a laboratory test to two herbicides (Stomp and Acetochlor) widely used in crop cultivation. The effects of concentration and site of herbicide action on the length of primary roots and hypocotyls as well as seedling fresh weight were studied. The results showed that the cultivars differed greatly in their sensitivity to the herbicide action. The difference in the growth responses was not only species-, but also cultivar-specific. In addition, there was a difference in the herbicide acting site on plants which depended on the kind of cucurbits crops. Based on the tolerance to the action of both herbicides the studied species can be classified as follows: watermelon, squash, pumpkin, muskmelon, cucumber. The tolerance differences of the studied cucurbits crops can be used in cultivation practice.

Keywords: cucurbits, herbicides, growth tolerance

Abbreviations: cv – cultivar, IR – inhibition rate

INTRODUCTION

Cucurbits are widely planted all over the world as valuable vegetables or fruits included broadly in human diet. Among the most popular species are watermelon (*Citrullus lanatus*(Thunb) Matsum and Nak), muskmelon (*Cucumis melo*), cucumber (C*ucumis sativus*), pumpkin (*Cucurbita spp*), canning pumpkin (*Cucurbita*

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moschata Duch.), and Squash (*Cucurbita pepo* L.). Calabash gourd (*Lagenaria vulgaris* Ser.), balsam pear (*Momordica charantia* L.) and dishcloth gourd (*Luffa cylindrica* L.) are not common species. The planting area of the cucurbits crops in the world has been increased from 5.5 million hectares to 8.7 million hectares during the last decade, and from 1.81 million hectares to 4.3 million hectares in China, respectively. Total yield was increased from 86 million tons to 155 million tons in the world and from 33.4 million tons to 110.9 million tons in China (FAO, 2005).

Heilongjiang Province of Northeast China is one of the major cucurbits production regions. The total planting area is over 225 thousand hectares with 130 thousand hectares of seed-use pumpkin, 95 thousand hectares of melon, water melon and pumpkin. Weed control, especially in the first four weeks after seedling emergence is of a crucial importance for preventing yield decline. The herbicide application is still the most efficient approach for weed control, although farming, hoeing, biological competition and plastic film mulching are also used.

There are basically three ways to apply a herbicide - pre-plant soil incorporation (PPI), pre-emergence (PRE) and post-emergence application. PRE application on pumpkin was safer compared with post-emergence (Umeda 1998). Ethalfiuralin injuries were reported in transplanted watermelon when PPI or PRE were adopted in North Carolina (Mitchem et al., 1997). Cultivar differences were found in watermelon after application of dinitroanaline herbicides (Darmstadt, 1979; Mitchem, et al., 1997; Monaco and Skroch, 1980). Bensulide has to be applied using PPI. It was primarily effective against annual grasses, but not for dicotyledonous species (Ahrens, 1994). Bensulide has also a long residual period, which can cause injury when small grains are grown in a rapid rotation (Frost et al., 1983; Monaco and Skroch, 1980). Ethalfluralin and dinitroaniline are the most commonly used herbicides in squash cultivation in Georgia. They can injure or kill emerging seedlings and reduce their yield (Kupatt et al., 1983; Monaco and Skroch, 1980). Darmstadt (1979) has reported 12% root injury to squash when ethalfluralin was applied at 1.4 kg·ha^{-1} as PRE followed by 1.9 cm of irrigation. When ethalfluralin was applied to the soil surface prior to transplanting squash, injury occurred because transplanting equipment had moved treated soil into contact with the plants. No injury was observed when ethalfluralin was applied over the plant tops immediately after transplanting (Kupatt et al., 1983; Precheur, 1983). Crop safety to halosulfuron varies depending on the cucurbits species. It was shown that melon (Cucwnis melo L.) was more susceptible than pumpkin (Bottenberg and Masiunas, 1997; Buker et al., 1998; Johnson and Mullinix, 1998).

In recent years, Stomp (33% pendimethalin emulsifiable) and Acetochlor have been commonly applied herbicides. It is known that cucurbits may be injured by herbicides to a different extent (Kupatt et al., 1983; Monaco and Skroch, 1980), and the susceptibility to the herbicide may vary depending on the species (Barth et al., 1995; Frost et al., 1983; Bottenberg and Masiunas, 1997; Buker et al., 1998; Johnson

and Mullinix, 1998; Umeda and Kai, 2002). However, no information is available as to how a herbicide can affect different cucurbits species.

Hence, the purpose of this study was to examine the tolerance of the main cucurbits species to the application of two common herbicides available in the market in order to reduce crop injury and avoid yield loss.

MATERIALS AND METHODS

Species and cultivars selected for this study are two cultivars of muskmelon (White Beauty and Feng Du), two cultivars of pumpkin (No1 pumpkin and Mei Tai), one watermelon cultivar (Green Farm No9), one squash cultivar (Jinghu No2) and two cultivars of cucumber (Longza No7 and Qi Feng). The herbicides used were Stomp (trade name) (generic name - N-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine; common name - pendimethalin), 33% emulsifiable concentrates produced by Melamine Limited Company International, (USA) and Acetochlor 50% emulsifiable concentrate (common name - Acetochlor; generic name - 2-chloro-N-(ethoxymethyl)-N-(2-ethyl-6-methylphenyl) acetamide) produced by Dalian Raiser Pesticides Limited Company Products.

The tested cultivars were treated with Stomp and Acetochlor separately at two concentration levels: 5 mg/kg and 10 mg/kg.

Fifity seeds from each cultivar were put into 5 Petri dishes and treated with 10 ml herbicide solution in triplicates (total 15 dishes for each treatment). The control was treated with 10 ml distilled water. All dishes (eight varieties × 5 dishes × 3 replicates × 2 concentrations × 2 herbicides = 480 dishes) were cultured for five days at 25°±1° C in an incubator. All dishes were checked daily and distilled water was added whenever was required.

The lengths of both primary roots and hypocotyls of the seedlings were measured five days from the onset of germination and the fresh weight of fifty seeds was determined.

The growth tolerance to the herbicides applied was expressed as an inhibition rate (IR) calculated according to the following formula:

$$\text{Inhibition rate (IR) (\%)} = \left(1 - \frac{\text{Averaged length of treatment}}{\text{Averaged length of control}}\right) \times 100\%$$

The average lengths (mm) of treated or control primary roots and hypocotyls emerging from 50 randomly selecting and germinating seeds were used for calculating IR. The negative values for the mean IR between three replications were considered as “zero” and no statistical analysis was done for the negative data. The significant differences between means were analyzed by SPASS 10.0 at level α=0.05.

RESULTS AND DISCUSSION

Growth tolerance of muskmelon cultivars to Stomp and Acetochlor application

In general, cv. Feng Du showed a significantly different growth response to the herbicide concentrations applied (Fig.1). It was found that Stomp had a significant inhibitory effect on the growth of primary roots, hypocotyls and seedling fresh weight of cv. Feng Du. The extent of IR of the hypocotyl was around 60% for both concentrations applied (5 and 10 mg/kg). The inhibition rate of seedling fresh weight was less than 40% and was lower for the primary root (less than 30%). Acetochlor application to cv. Feng Du led also to an inhibition effect. The value for IR for seedling primary roots was higher when compared with Stomp application. However, the inhibition rate for the other studied parameters - hypocotyl and seedling fresh weight was lower. Therefore, the site of the inhibitory action of Stomp and Acetochlor in muskmelon cv. Feng Du during germination differed greatly. IR reached significant values in both treatments, thus suggesting that these herbicides were not applicable for this cultivar.

In comparison, the other studied muskmelon cv. White Beauty showed higher growth tolerance to Stomp application, but in contrast, it was very sensitive to the application of Acetochlor. The inhibition rate of cv. White Beauty in response to Stomp application at 5 mg/kg was “zero” while at 10 mg/kg it was insignificantly low (Fig.2). In contrast to Stomp, the application of Acetochlor showed significant inhibition effects on the root growth and seedling fresh weight. The inhibition rate of Acetochlor on hypocotyl growth was over 50% while on the root length and fresh

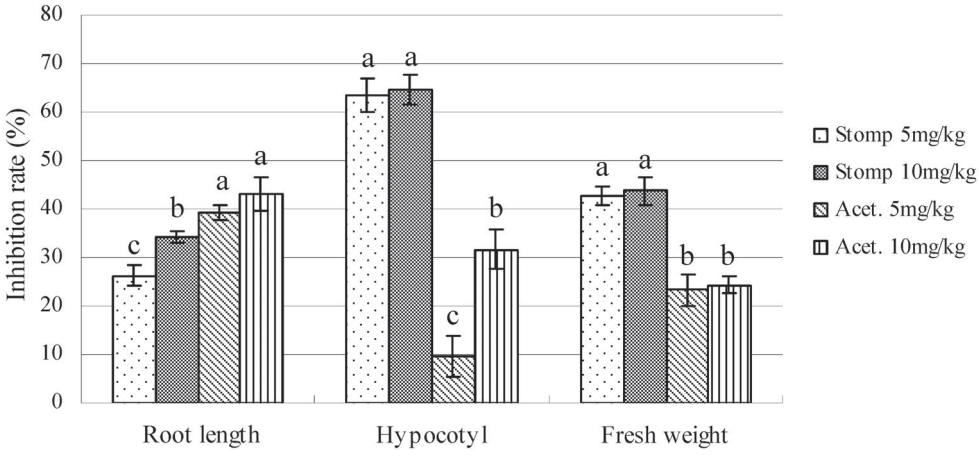

Fig. 1 The inhibition effect of Stomp and Acetochlor on Feng Du melon

*Inhibition rate (%) = (1-Value of treatments/Value of control)*100%

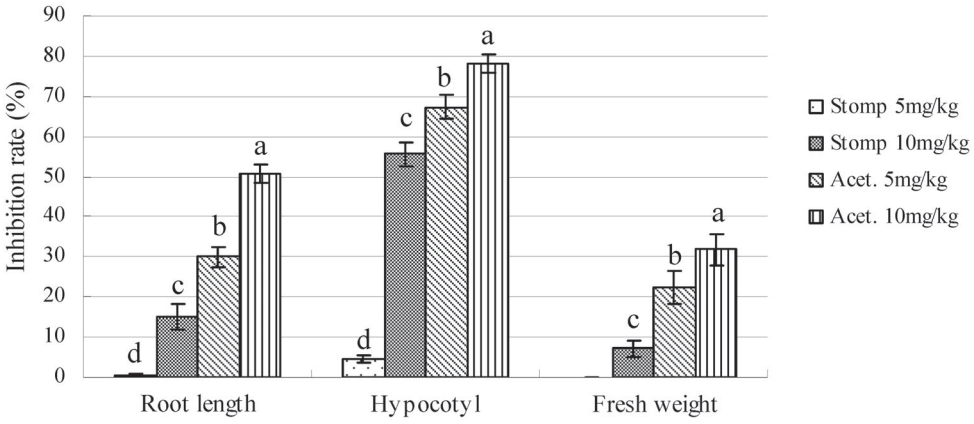

Fig. 2 The inhibition effect of Stomp and Acetochlor on White Beauty melon

weight it exceeded 20% at both concentrations applied. Therefore, compared with Acetochlor Stomp was more applicable for muskmelon cv. White Beauty.

Analyses of the obtained data suggest that Stomp is harmless and can be used during cultivation of White Beauty while Acetochlor can be more efficient when cv. Feng Du is cultivated. The herbicide action depended on the applied concentrations.

Growth tolerance of watermelon cultivars to Stomp and Acetochlor application

Our results showed significant growth tolerance of water melon cv. Green Farm No9 to both herbicides. When Acetochlor was applied at a concentration of 10 mg/kg, the calculated IR values for all measured parameters (primary root and hypocotyl length or seedling fresh weight) was only 6%. The calculated IR was almost "zero" when Stomp was applied at both studied concentrations. The results suggest that Stomp and Acetochlor will be appropriate for use in cv. Green Farm No9 cultivation (Fig.3)

Growth tolerance of cucumber cultivars to Stomp and Acetochlor application

Cucumber cv. Longza No7 showed low growth tolerance to Acetochlor, and higher tolerance to Stomp at the lower concentration of 5 mg/kg. Stomp applied at 5 mg/kg did not inhibit the studied parameters while the application of Acetochlor at both studied concentrations caused significant injury effects (ranging between 30 and 50% for roots and hypocotyls). Therefore, Stomp applied at a concentration of 5 mg/kg will be more acceptable for application in Longza N7 cultivation (Fig.4).

Cucumber cv. Qi Feng was very sensitive to the application of both studied herbicides. Even at a concentration of 5 mg/kg both herbicides inhibited root and hypocotyl growth more than 40 % (Fig 5). Therefore, it can be concluded that cv. Longza

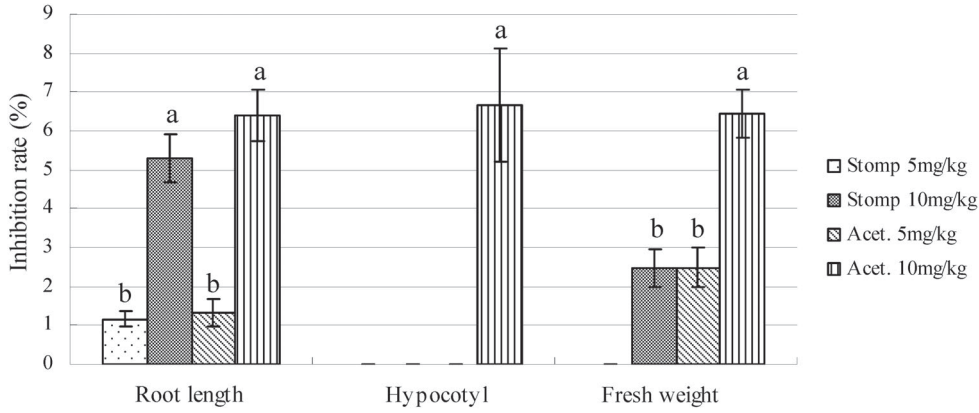

Fig. 3 The inhibition effect of Stomp and Acetochlor on Green Farm No9 watermelon

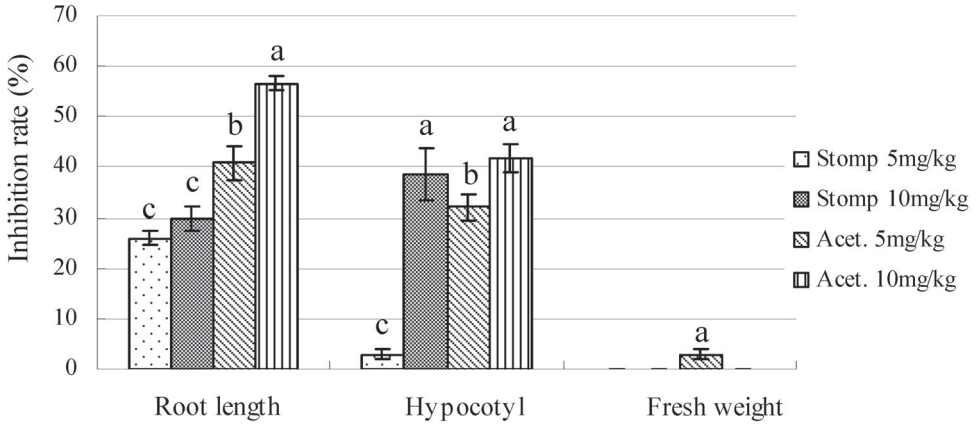

Fig. 4 The inhibition effect of Stomp and Acetochlor on LongZa No7 cucumber

N7 is more tolerant especially to Stomp and can be grown successfully under lower herbicide concentrations while cv. Qi Feng being more sensitive to the action of both herbicides cannot be cultivated efficiently.

Growth tolerance of squash cultivars to Stomp and Acetochlor application

Squash cv. Jinghu No2 showed higher tolerance to both studied herbicides (Fig.6). The IR of all studied parameters after application of both herbicides at a concentration of 5 mg/kg was negligible (less than 10%). The growth of root and hypocotyls tolerated the concentration of Stomp as high as 10 mg/kg without visible negative symptoms. Only the fresh biomass of seedlings showed an inhibition rate of 30 % at

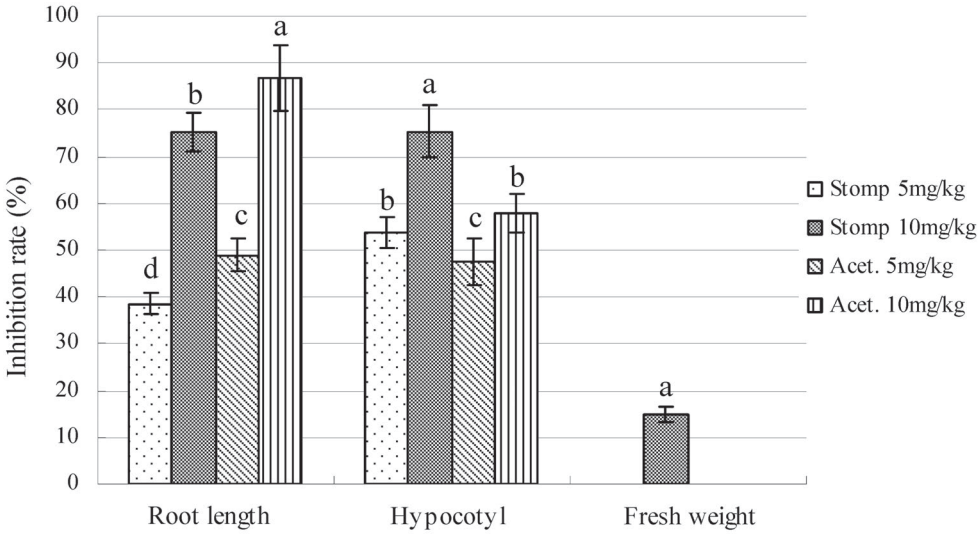

Fig. 5 The inhibition effect of Stomp and Acetochlor on QiFeng cucumber

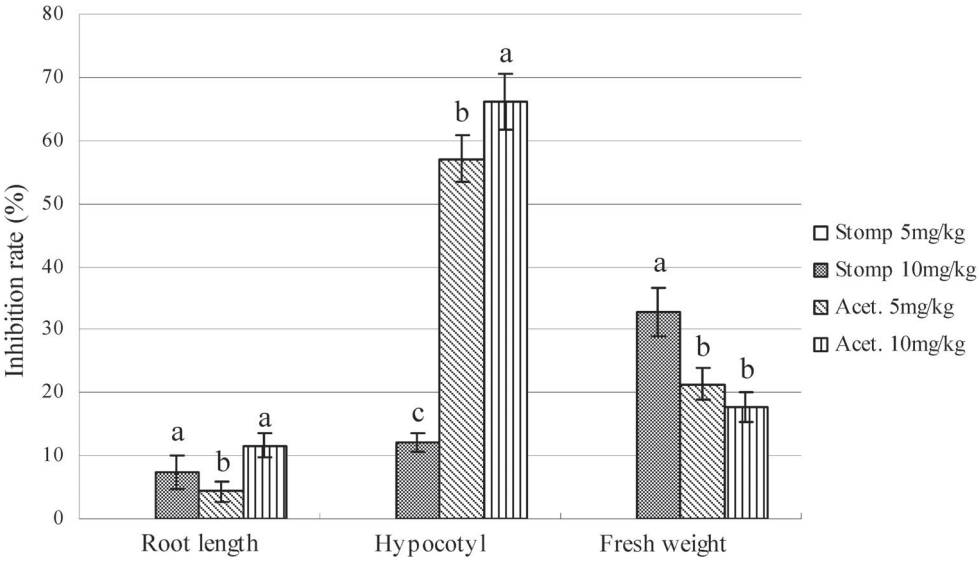

Fig. 6 The inhibition effect of Stomp and Acetochlor on JingHu No2 squash

10 mg/kg. The inhibition of hypocotyl was higher than 55 % at 5 mg/kg and exceeded 65 % at 10 mg/kg of Acetochlor. Thus, Stomp can be considered as relatively harmless to cv. Jinghu No2 while Acetochlor is harmful and not applicable to this cultivar. These results are not applicable for all known cultivars because plant response to the action of herbicides can vary considerably and has to be assessed before their use in practice (Frost et al., 1983; Barth et al., 1995) (Fig.6).

Growth tolerance of pumpkin cultivars to Stomp and Acetochlor application

The application of the two herbicides at both concentrations affected the germination of pumpkin cv. No1 to a different extent (Fig.7). Acetochlor at 5 mg/kg almost had no inhibitory effect on the primary root, but inhibited significantly seedling hypocotyl and fresh weight. Stomp inhibited root and hypocotyl growth (40 % - 55 %), while Acetochlor applied at the same concentration was much harmless to growth. These results suggest that the application of Acetochlor to cv. N1 will be more harmless (Fig.7).

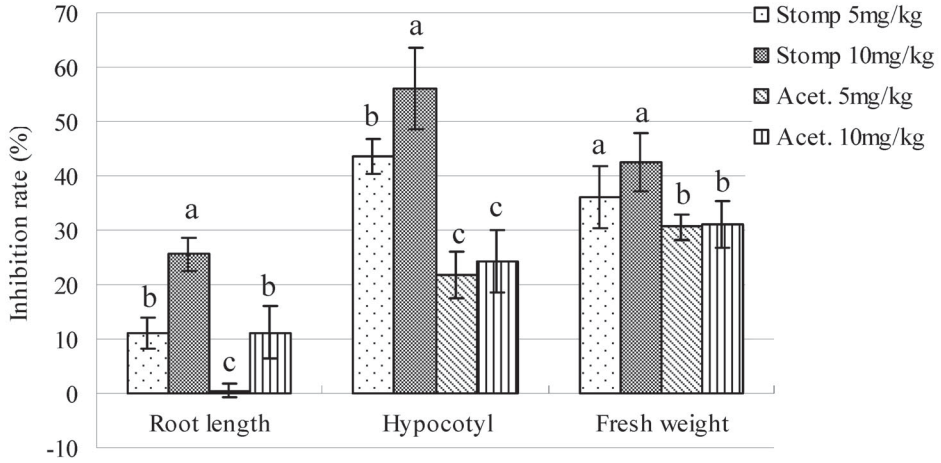

Fig. 7 The inhibition effect of Stomp and Acetochlor on NO1 pumpkin

The negative growth reaction of hypocotyl and fresh weight of cv. Mei Tai to the application of Stomp at 5 mg/kg was found to be negligible (Fig.8). However, when the higher herbicide concentration was used, the IR of roots and hypocotyls increased significantly. Likewise, the inhibition rate of roots and hypocotyls was high when Acetochlor was applied at both studied concentrations. The application of Stomp at 5 mg/kg during cultivation of cv. Mei Tai is applicable while the use of Acetochlor can be avoided (Fig.8).

Conclusions

The growth tolerance of cucurbits species to the application of the herbicides Stomp and Acetochlor varied significantly in dependence of the studied species and cultivars. Based on the tolerance to the action of both herbicides the studied species can be classified as follows: watermelon, squash, pumpkin, muskmelon, cucumber. The difference in the growth responses was not only species-, but also cultivar-specific. In addition, the small-seed representatives of the studied species exhibited higher sensitivity to the application of Stomp and Acetochlor in contrast to the large-seed

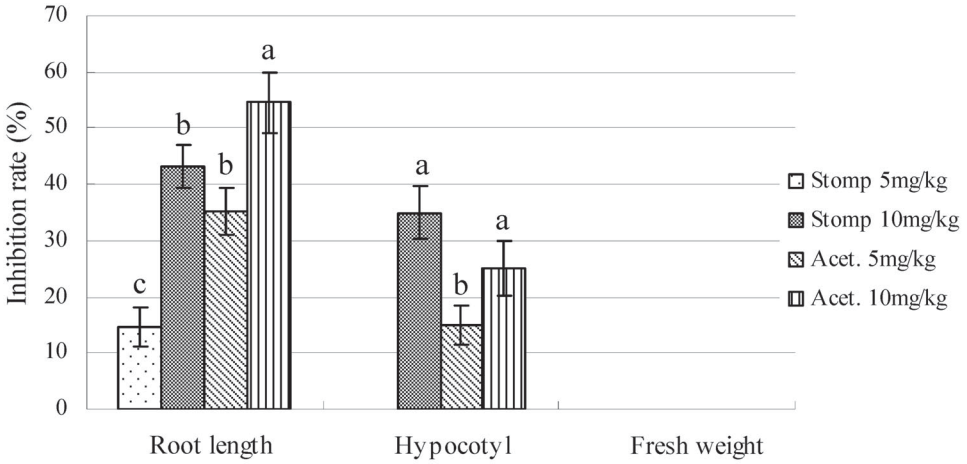

Fig. 8 The inhibition effect of Stomp and Acetochlor on MeiTai pumpkin

species. According to the applicability of these herbicides in cultivation practice based on their harmfulness, the species can be classified as follows: watermelon, squash, pumpkin, muskmelon, cucumber. Our results confirm the common opinion that an injury test for applicability of a herbicide has to be conducted before its application in practice. Farmers should adopt an appropriate cultivation and herbicide application methods in order to avoid any injury caused by herbicides.

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