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Effects of Grape Seedlings Intercropping with Floricultural Accumulator Plants on Soil Enzyme Activities under Cadmium Stress

Piao Liu[1,a], Huifen Zhang[2,b] and Lijin Lin[1,c]*

[1]Institute of Pomology and Olericulture, Sichuan Agricultural University, Chengdu, Sichuan, China

[2]College of Horticulture, Sichuan Agricultural University, Chengdu, Sichuan, China

[a]liufei569@qq.com, [b]1042335395@qq.com, [c]llj800924@qq.com

*Corresponding author. Piao Liu and Huifen Zhang contributed equally to this work.

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Abstract: The effects of intercropping with four floricultural accumulator plants (*Helianthus annuus, Cosmos sulphureus, Cosmos bipinnata, Impatiens balsamina*) on soil enzymes activity and soil organic matter of grape seedlings under cadmium (Cd) stress were studied by a pot experiment. The results showed that intercroping *H. annuus* reduced the content of soil organic matter and soil catalase activity as compared with monoculture of grape seedlings. The intercropping *C. sulphureus* reduced the soil urease activity content and the intercropped *C. bipinnata* decreased the soil sucrase activity content. Only the grape seedlings intercropping *I. balsamina* increase soil enzyme activity. Therefore, the intercropping of *I. balsamina* grape seedlings can increase soil enzyme activity and improve soil fertility.

Introduction

The cadmium (Cd) is one of the most toxic heavy metal elements that harmful to the growth of plants and human health [1]. With the development of mining, smelting, thermal power generation and industrialization, soil heavy metal pollution has become a worldwide problem [2]. As a component of soil, the activity of enzyme can sensitively reflect the direction and intensity of biochemical reaction in soil [3]. Grape is one of the longest cultivated fruit tree in the world, which is an important branch of China's agricultural industry, with high nutritional and economic value [4]. It has been found that intercropping is able to improve the soil environment and make full use of resources [5-6]. *Helianthus annuus* [7], *Cosmos sulphureus* [8], *Cosmos bipinnata* [9], *Impatiens balsamina* [10] were used to intercropping with grape measure soil enzyme changes in study, and effects of intercropping grape seedlings and four floricultural accumulator plants on soil enzyme activities were studied. The purpose of this experiment is to find the best floricultural accumulator plant and grape intercropping model to promote soil enzyme activity.

Materials and Methods

Materials Collection. The seeds of floricultural accumulator plants (*H. annuus*, *C. sulphureus*, *C. bipinnata*, *I. balsamina*) were collected from the farmland of Chengdu Campus of Sichuan Agricultural University and were put into the tray to germinate in April, 2016. The cultivar of grape is Kyoho with cutting seedlings. The fluvo-aquic soil samples were collected from the farmland at Chengdu Campus of Sichuan Agricultural University in April, 2016.

Experimental Design. In May 2016, three uniform-sized cutting seedlings (the shoots were about 15 cm) of Kyoho grape were transplanted into pot for monoculture. One uniform-sized seedling (two pairs leaves expanded) of each floricultural accumulator plant and two grape seedlings were transplanted into each pot for intercropping. The five treatments in experiment were monoculture of grape, grape intercropped with *H. annuus*, grape intercropped with *C. sulphureus*, grape intercropped with *C. bipinnata* and grape intercropped with *I. balsamina*. Three replicates per treatment and the pots placed completely random. The distance between pots was 15 cm, and the pot position exchanged aperiodically to weaken the impact of the marginal effects. The soil moisture content was maintained at 80% of field capacity until the plants were harvested. After

removing the sample from the plant roots, stones, etc, and then dry at room temperature, grinding, 6.72-mm sieve, bagged airtight standby.

Statistical Analyses. Statistical analysis was carried out by using SPSS 20.0 statistical software. The data were analyzed by one-way ANOVA, with the least significant difference at the 5% confidence level.

Results and Discussion

Soil Organic Matter. The intercropping of grape seedlings and four floricultural accumulator plants significantly increased the content of soil organic matter (Fig. 1). Soil organic matter content by intercropping arrangement: intercropping with *I. balsamina* > intercropping with *C. sulphureus* > Intercropping with *C. bipinnata* > intercropping with *H. annuus* (Fig. 1). Compared with monoculture, intercropping with *I. balsamina* and intercropping with *C. sulphureus* significantly increased organic matter content in grape seedlings, respectively is 23.9% ($p < 0.05$), 9.6% ($p < 0.05$), intercropping with *C. bipinnata* and intercropping with *H. annuus* did not significantly increase the content of soil organic matter in grape seedlings (Fig. 1).

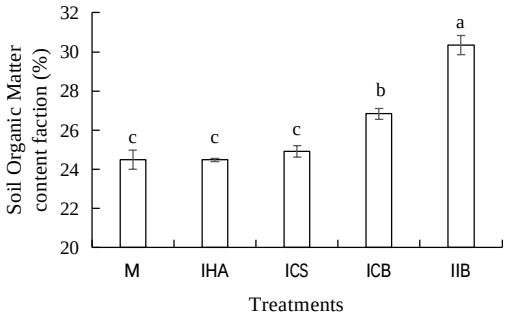

Fig. 1 Soil organic matter. Different lowercase letters indicate significant differences based on one-way analysis of variance in SPSS 20.0 followed by the least significant difference test ($p < 0.05$). M = monoculture, IHA = intercropping with *H. annuus*, ICS = intercropping with *C. sulphureus*, ICB = intercropping with *C. bipinnata*, IIB = intercropping with *I. balsamina*.

Soil Catalase Activity. Intercropping with *I. balsamina* , intercropping with *C. sulphureus* and intercropping with *C. bipinnata* increased the amount of soil catalase activity, while intercropping with *H. annuus* reduced soil catalase activity (Fig. 2). The contents of catalase activity in the grape seedlings were arranged in the intercropping mode: intercropping with *C. sulphureus* > intercropping with *C. bipinnata* > intercropping with *I. balsamina* > intercropping with *H. annuus* (Fig. 2). So, under the stress of Cd, intercropping treatments can improve the soil catalase activity.

Soil Phosphatase Activity. Intercropping with H.*annuus*, intercropping with C. *sulphureus,* intercropping with *C. bipinnata,* intercropping with *I. balsamina* increased of soil phosphatase activity by 51.5% ($p < 0.05$), 22.3% ($p < 0.05$), 19.8 % ($p < 0.05$), 30.9% ($p < 0.05$), under Cd stress, compared with monoculture, respectively (Fig. 3). The content of soil phosphatase activity was intercropped as follows: intercropping with *H. annuus* > intercropping with *I. balsamina* > intercropping with *C. sulphureus* > intercropping with *C. bipinnata* (Fig. 3).

Soil Urease Activity. Compared with monoculture, intercropped with *I. balsamina*, intercropping with *H. annuus*, and intercropping with *C. sulphureus* on the soil urease activity content is not affected (Fig. 4). Intercropping with *H. annuus* increased soil urease activity content, increase of 16.3% ($p < 0.05$) (Fig. 4). Soil urease activity content intercropping: intercropped with *H. annuus* > intercropped with *I. balsamina* > intercropping with *C. sulphureus* > intercropping with *C. bipinnata* (Fig. 4).

Soil Invertase Activity. Intercropping with *H. annuus*, intercropping with *C. sulphureus* and intercropped with *I. balsamina* increased soil invertase activity content by 13.4% ($p < 0.05$), 14.3% ($p < 0.05$), 4.9% ($p < 0.05$), intercropping with *C. bipinnata* decreased soil sucrase activity by 5.8% ($p < 0.05$) (Fig. 5). Soil invertase activity content was intercropped as follows: intercropping with *C. sulphureus* > intercropping with *H. annuus* > intercropped with *I. balsamina* > intercropping with *C.bipinnata* (Fig. 5).

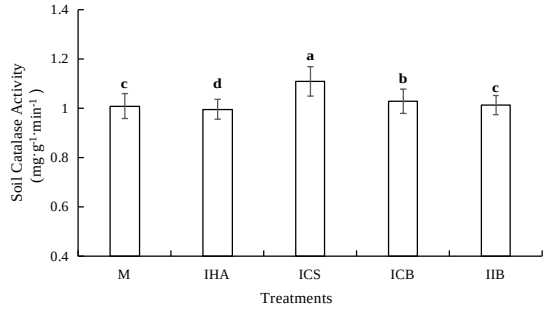

Fig.2 Soil Catalase Activity. Different lowercase letters indicate significant differences based on one-way analysis of variance in SPSS 20.0 followed by the least significant difference test ($p < 0.05$). M = monoculture, IHA = intercropping with *H. annuus*, ICS = intercropping with *C. sulphureus*, ICB = intercropping with *C. bipinnata*, IIB = intercropping with *I. balsamina*.

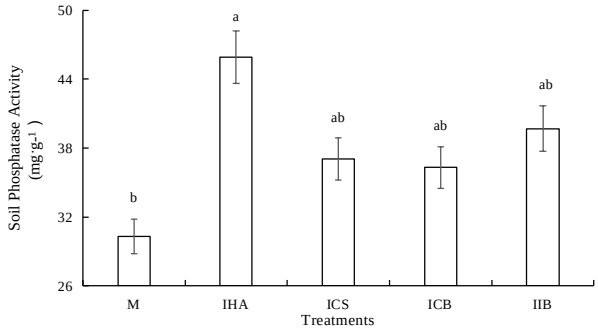

Fig.3 Soil Phosphatase Activity. Different lowercase letters indicate significant differences based on one-way analysis of variance in SPSS 20.0 followed by the least significant difference test ($p < 0.05$). M = monoculture, IHA = intercropping with *H. annuus*, ICS = intercropping with *C. sulphureus*, ICB = intercropping with *C. bipinnata*, IIB = intercropping with *I. balsamina*.

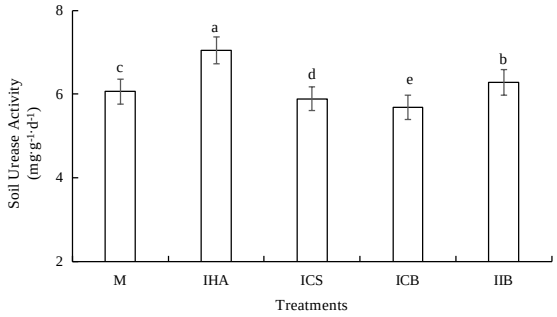

Fig.4 Soil Urease Activity. Different lowercase letters indicate significant differences based on one-way analysis of variance in SPSS 20.0 followed by the least significant difference test ($p < 0.05$). M = monoculture, IHA = intercropping with *H. annuus*, ICS = intercropping with *C. sulphureus*, ICB = intercropping with *C. bipinnata*, IIB = intercropping with *I. balsamina*.

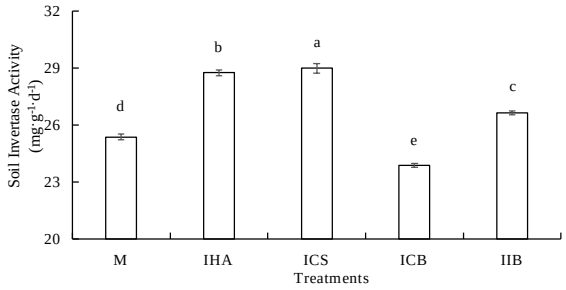

Fig.5 Soil Invertase Activity. Different lowercase letters indicate significant differences based on one-way analysis of variance in SPSS 20.0 followed by the least significant difference test ($p < 0.05$). M = monoculture, IHA = intercropping with *H. annuus*, ICS = intercropping with *C. sulphureus*, ICB = intercropping with *C. bipinnata*, IIB = intercropping with *I. balsamina*.

Conclusions

Under Cd stress, grape seedlings intercropping with *H. annuus*, *C. sulphureus, C. bipinnata* and *I. balsamina* affected soil enzyme activity. Compared with the grape seedlings monoculture, intercropped with *I. balsamina* significantly increased all the content of soil enzymes activity, intercropping with *H. annuus* reduced the content of soil organic matter and soil catalase activity, intercropping with *C. sulphureus* reduce soil urease activity content, intercropping with *C.*

bipinnata reduced content of soil urease activity, and soil invertase activity. These results suggest that interplanting with *I. balsamina* between grape seedlings can increase soil enzyme activity and increase soil fertility, while other intercropping treatments do not.

Acknowledgements

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