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Effects of *Cucumis* and *Cucurbita* rootstocks on vegetative traits, yield and quality in 'Tainan No. 1' cucumber

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ABSTRACT

'Tainan No.1' cucumber, an F1 hybrid, is powdery-mildew resistant and is, therefore, fit for greenhouse-culture. Soil-borne diseases in cucurbits have gained increasing importance with intensive cultivation of these crops. In the present experiment, cucumber cv. 'Tainan No. 1' was grafted onto two rootstocks, viz., *Cucumis* and *Cucurbita*. Non-grafted cucumber plants were used as the Control. Results revealed that both kinds of grafted plants had similar graft-survival rate, and, better vegetative growth than non-grafted ones; however, between the two rootstocks, grafted plants did not differ in vegetative growth or yield. Further, plants grafted on *Cucumis* had significant effect on fruit quality. In is therefore recommended that grafting procedure in cucumber greenhouse-culture can be practiced on *Cucumis*.

Key words: *Cucumis*, *Cucurbita*, cucumber, graft, soil-borne diseases

INTRODUCTION

The cucumber (*Cucumis sativus* L.) is a widely cultivated plant of the gourd family, *Cucurbitaceae*. On account of F1 hybrids of cucumber possessing better quality, high yield, early-maturity, uniformity, etc., these have almost fully replaced traditional, open-pollinated varieties for greenhouse-culture. Intensified protected-cultivation of cucurbits leads to conditions favorable to several pathogens, especially, soil-borne diseases. Fumigation of soil with methyl bromide to control soil-pathogens was considered as one of the main factors for successful cultivation of cucurbits. With withdrawal of methyl bromide, cucurbits growers are increasingly looking for alternatives to this fumigant.

Grafting is an asexual plant-propagation method and has become an essential technique for repeated production of crops in greenhouses. Grafting of vegetables was first attempted in Korea and Japan in the late 1920s by grafting watermelons onto gourd rootstocks. Lee (1994) reported the gradual increase in use of grafted vegetables in Japan, Korea and some other Asian and European countries, and currently includes melon, cucumber, watermelon, tomato, eggplant and pepper to being grafted before transplantation. Grafting vegetables onto compatible rootstocks offers a number of advantages like resistance to soil-pathogens, increase in yield (Bletsos *et al*, 2003) and greater tolerance to temperature and salt stresses (Ahn *et al*, 1999; Rivero *et al*, 2003). Sakata *et al* (2008) showed that cucumber could be grafted onto different rootstocks, including *Cucumis* spp., *Cucurbita* spp., *Cucurbita* interspecific hybrids, bottle gourd, wax gourd, fig-leaf gourd and luffa. Each rootstock has its specific function. Marukawa and Takatsu (1969) reported fig-leaf gourd as providing better cold-tolerance and resistance to *Fusarium* wilt while having a high affinity for cucumber, making it the most commonly used rootstock in the crop.

A majority of cucumbers grown in Taiwan when grafted onto *Cucurbita* spp. cv. Heroes, show superior tolerance to soil-borne diseases, but often lack seed formation. *Cucumis* spp. cv. Qingpi, originally from an open-pollinated variety and primarily used for processing in Taiwan, has a high commercial potential. As grafting of herbaceous vegetables continues to gain popularity, plant breeders need to be ready and equipped with rootstock germplasm. Grafting is a viable option to growers for managing biotic and abiotic stresses which limit yield and quality (King *et al*, 2010). The purpose of our study was to compare effects of *Cucumis* and *Cucurbita* rootstocks on vegetative growth, yield and quality in cucumber and identify new rootstocks to replace conventional ones to exploit economic potential of cucumber cultivation.

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MATERIAL AND METHODS

The present study was conducted at Yichu Branch Station, Tainan District Agricultural Research and Extension Station, Chiayi County, Taiwan, during 2009-2010. Cucumber (*Cucumis sativus*) cv. 'Tainan No.1' was grafted onto two rootstocks, viz., *Cucumis* cv. Qingpi and *Cucurbita* cv. Heroes. Approach-grafting is best done when the rootstock and scion both have similar stem-thickness. To obtain an equal stem-diameter in scion and the rootstock, rootstock seeds were planted ten days earlier than cucumber seeds; non-grafted cucumber plants were used as the Control. To facilitate graft-union, acclimatization is important, whereby the light was maintained at about 3000 Lux, air temperature at 25ºC and relative humidity at 95% for sixteen days. Graft-survival rate was estimated 20 days after grafting and was expressed as percentage of total number of plants grafted.

After the graft was firmly established, seedlings were transplanted to soil. The experiment was laid out in Completely Randomized Block design. Each treatment was replicated four times, with twenty plants per replication in the greenhouse at a spacing of 1.5×0.75m. The following vegetative / qualitative traits were recorded: survival rate of grafted seedlings; horticultural traits (including parthenocarpy and gynoecious habit) from planting to harvest, including final main-stem length, scion diameter, rootstock diameter, internode length and number of leaves. Fruit weight was estimated and soluble solids content of juice (extracted from the central endocarp) was determined with a hand-held refractometer. Data were statistically analyzed.

RESULTS AND DISCUSSION

Most greenhouses in Taiwan are subjected to continuous cropping in fruit-bearing vegetable production, which lowers the yield and diminishes quality of the produce. Takahashi (1984) reported 68% reduction in continuous vegetable cropping in Japan, caused by soil-borne diseases and nematodes. As soil-sterilization is difficult, grafting has become an essential technique for production of repeat crops in greenhouses. Many grafting methods are available for different types of fruit-bearing vegetables including tomato. Cleft-grafting and cut-grafting are popular in watermelon. Oda (1999) reported survival rate in grafted *Cucurbitaceae* plants to be higher when approach-grafting was used.

In this experiment, cucumber cv. 'Tainan No. 1' was grafted by approach-grafting onto two different rootstocks. Survival rates when grafted onto *Cucumis* and *Cucurbita* were 80% and 78%, respectively (Table 1), i.e., similar graft-success rate. Though Traka-Mavrona *et al* (2000) reported that difference in stem diameter of rootstock and scion reduced graft-survival rate. However, in this experiment, acclimatization provided good conditions for rootstock/scion union to overcome disparate stem-diameter. Moreover, cucumber cv. 'Tainan No. 1' grafted onto various rootstocks retains all the desired horticultural traits (Table 1).

Vegetative growth of grafted plants differed significantly and indicated superior growth potential compared to non-grafted Controls. Non-grafted plants suffered from serious soil-borne diseases, including *Phytophthora* blight, Gummy-stem blight and *Fusarium* wilt (Fig. 1). Data on final main-stem length, scion diameter, rootstock diameter, internode length and leaf number are presented in Table 2. All the traits under study were affected by rootstock-use. Lee and Oda (2003) reported grafted plants as showing different vegetative growth responses owing to vigor of the rootstock and rootstock-scion compatibility. Longest final main-stem was observed in plants grafted onto *Cucurbita*. However, no significant differences were found in final main-stem length, scion / rootstock diameter, internode length and leaf number among plants grafted onto the two different rootstocks (Table 2). However, final main-stem length and leaf number in grafted plants were significantly higher than in non-grafted ones.

Table 1. Effect of rootstock on survival rate and horticultural traits in grafted cucumber

Rootstock	Survival rate (%)	Gynoecious type	Parthenocarpic type
Cucumis	80	Yes	Yes
Cucurbita	78	Yes	Yes
Non-grafted	—	Yes	Yes
T-test	NS	NS	NS

NS = Non-significant

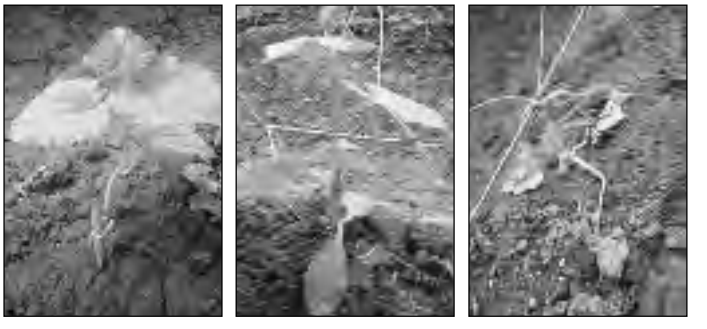

Fig 1. Performance of 'Tainan No. 1' cucumber grafted onto two different rootstocks: *Cucumis* (left), *Cucurbita* (centre) and non-grafted (right) planted on the same date in the greenhouse at Yichu Branch Station

Table 2. Effect of rootstock on vegetative traits in grafted cucumber

Rootstock	Final main-stem length (cm)	Scion diameter(cm)	Rootstock diameter (cm)	Internode length (cm)	No. of leaves
Cucumis	220±7	1.3±0.1	1.3±0.2	5.5±0.3	122±15
Cucurbita	228±9	1.3±0.3	1.3±0.2	5.6±0.2	124±12
Non-grafted	201±5	1.1±0.2	1.1±0.1	4.6±0.3	108±11
T-test	*	NS	NS	NS	*

NS = Non-significant; *Significant at *P* d" 0.05 level

Table 3. Effect of rootstock on fruit traits in grafted cucumber

Rootstock	Fruit length (cm)	Fruit width (cm)	Fruit weight (g)	Total Soluble Solids (°Brix)	Yield (t/ha)
Cucumis	22.8±0.8	2.5±0.3	92±1.5	4.6±0.3	8.0±0.8
Cucurbita	23.4±1.0	2.6±0.2	94±1.2	3.3±0.2	8.1±0.9
Non-grafted	23.5±0.7	2.6±0.3	95±1.5	3.3±0.1	5.9±0.9
T-test	NS	NS	NS	*	**

NS = Non-significant; Significant at *P* d" 0.05 or 0.01 level, respectively

Superior vigor and vegetative growth in grafted plants can be explained by their resistance to soil-borne diseases (Lee, 1994), better root-system activity in the rootstock (Salehi *et al*, 2009) leading to increased water and plant nutrient uptake, higher endogenous levels of hormones (Zijlstra *et al*, 1994) and tolerance of the rootstock to other unfavorable soil-conditions (Rivero *et al*, 2003).

It has been stated that grafting onto *Cucurbita* rootstock had an adverse effect on cucumber production in Taiwan. In our experiment, though, we could not detect any negative effect on cucumber fruit quality using *Cucurbita* rootstock. In addition, there was no significant difference between the two rootstocks in grafting in terms of fruit length, fruit width or fruit weight (Table 3). Moreover, grafting resulted in significantly higher soluble solid content and total yield on both the rootstocks, especially when cucumber was grafted onto *Cucumis*. However, total yield did not vary with rootstock (Table 3). In this study, higher fruit yield was obtained in plants grafted onto *Cucurbita* rootstock. This may be due to various factors such as increase in uptake of water and nutrients with the widespread root-system of the rootstock (Salehi *et al*, 2009) and due to improved tolerance to soil-borne diseases (Miguel *et al*, 2004).

Improvement in quality of the vegetable by grafting has been demonstrated in melon grafted onto *Cucurbita* spp. (Kamiya and Tamura, 1969) and watermelon grafted onto squash (Yamasaki *et al*, 1994). The most obvious reason why rootstocks affect scion fruit quality is rootstock/scion incompatibility, which induces undergrowth or overgrowth of the scion leading to decreased water and nutrient flow through the graft-union, with resultant wilting (Davis *et al*, 2008). Various rootstocks affect cucumber quality negatively, besides causing shortening of fruits (Muramatsu, 1981) and decreased soluble solids content (Zhu *et al*, 2006). In our study, cucumber when grafted onto *Cucumis* was seen to be compatible with normal vegetative growth response and good fruit traits. All in all, these results suggest that *Cucumis* is a new rootstock that can replace the existing cucumber production and its economic potential can be exploited.

Thus rootstock had a significant effect on survival rate, vegetative growth, fruit yield and fruit quality. Cucumber grafted onto *Cucumis* rootstock showed good rootstock-scion combination, better tolerance to soil-borne diseases, better growth, yield and quality. Therefore, it is recommended that *Cucumis* can be used as a new rootstock with economic potential, in cucumber production.

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