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Grafting Cucumber onto Interspecific *Cucurbita* Hybrid Rootstocks to Improve Productivity and Control wilt Disease Caused by *Fusarium oxysporum* f. sp. *cucumerinum*

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ABSTRACT

Commercial cucurbits such as cucumber, melon and watermelon are commonly grafted onto interspecific *Cucurbita* hybrid rootstocks to increase yield and mange soil-borne diseases. This study conducted in private farm in Qallien district in Kafr El-Sheikh Governorate northern Egypt during the period from 2018 to 2020 to identify local Fusarium wilt-resistant interspecific *Cucurbita* hybrid rootstocks which provide high grafting compatibility with hybrid cucumber scions. Results revealed that disease severity percentage in all interspecific hybrids (0 to 45%) was significantly lower than susceptible commercial cucumber Junco F_1 (73.4%). Seven out of the 20 individual hybrids (A02, B02, D02, F01, G02, H01 and I02) were resistant or highly resistant to Fusarium wilt with a mean disease severity ≤ 25%. Results from the greenhouse trials confirmed high levels of resistance in three interspecific hybrids (G02, H01 and I02) which were used as rootstocks for cucumber Junco F_1. Fruit yield parameters were increased significantly in grafted cucumber Junco F_1 onto wilt-resistant interspecific hybrids compared to un-grafted cucumber. Highly significant differences in anatomical structure were observed between wilt-resistant interspecific hybrid rootstock H01 and susceptible check Junco F_1. Fruit yield parameters of grafted cucumber Junco F_1 were negatively correlated with disease severity. The interspecific hybrids evaluated in the present study could be promising rootstocks to increase productivity and manage soil-borne diseases for commercial production of major cucurbits in Egypt.

Keywords: Biotic stress resistance, cucumber, cucurbits, Fusarium wilt, grafting, interspecific hybrids, pumpkins

INTRODUCTION

The Cucurbitaceae is a large family that includes major vegetable crops such as cucumber (*Cucumis sativus* L.), melon (*Cucumis melo* L.), watermelon [*Citrulus lanatus* (Thunb.) Matsum. & Nakai], summer squash (*Cucurbita pepo* L.) and pumpkin (*Cucurbita maxima* Duch. and *C. moschata* Duch.). These crops provide important nutritional benefits to consumers and are considered economically important crops worldwide. However, continuous greenhouse cropping of cucurbits has caused severe epidemics of soil-borne diseases, especially those caused by *Fusarium* species and root-knot nematodes (RKN) (*Meloidogyne* spp.).

Fusarium oxysporum f. sp. *cucumerinum* is one of the most destructive pathogen in cucurbit crops that causes vascular, necrotic lesions and root rot, which ultimately lead to wilting and severe yield loss especially when the vigor of cucurbit plants is significantly reduced under unfavorable micro climatic conditions (Vakalounakis *et al*., 2004; Tok and Kurt, 2010). Furthermore, Fusarium wilt can manifest itself in young and mature plants throughout all growing stages (Ahn *et al*., 1997).

Grafting in cucurbits is a primary goal to avoid damage caused by soil-borne diseases including Fusarium in cases where genetic or chemical approaches to disease management are not available (Lee and Oda, 2003; Louws *et. al*., 2010). Additionally, grafted plants are often more tolerant to abiotic stress, and horticultural traits such as earliness and yield increase can be improved (Schwarz *et al*., 2010; Edelstein *et al*., 2011). Commercial cucurbits such as watermelon (*Citrullus lanatus*) and melon can be grafted onto rootstocks of the same species (intraspecific) or onto cucurbits from other species (interspecific) such as interspecific hybrids between *C. maxima* and *C. moschata* (Karaagac and Balkaya, 2013; Edelstein *et al*., 2014; Thies *et al*., 2015). Interspecific hybrids between *C. maxima* and *C. moschata* have commonly used rootstocks for commercial cucurbits for the control of biotic and abiotic stresses and to enhance scion vigor (Hassel and Daley 2015), providing significant economic returns to farmers.

Crosses among *Cucurbit* species have been made successfully and obtained fruit and fertile seeds through traditional pollination and additional techniques such as embryo rescue, protoplast fusion, mixed pollen pollination, and bud pollination (Rakha *et al*., 2012; Plazas *et al*., 2016; Rakha, 2017). However, interspecific rootstocks seed production is expensive as well as its germination is problematic (Edelstein *et al.* 2007; Rakha, 2017). Breeding of appropriate interspecific rootstocks and testing of grafting compatibility are still lacking in Egypt.

The objectives of this study were to 1) evaluate interspecific hybrids derived from the crosses between *C. maxima* and *C. moschata* against *F. oxysporum* f. sp.

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cucumerinum, 2) evaluate cucumber productivity of commercial hybrid Junco F_1 grafted onto identified Fusarium wilt-resistant interspecific hybrids and 3) investigate anatomical structure differences between Fusarium wilt-resistant interspecific hybrid H01 and susceptible commercial cucumber hybrid Junco F_1.

MATERIALS AND METHODS

Plant materials

Twenty interspecific hybrids namely; A01, A02, B01, B02, C01, C02, D01, D02, E01, E02, F01, F02, G01, G02, H01, H02, I01, I02, J01 and J02 were developed from the interspecific hybridizations between ten accessions of *C. maxima* (MAX2, MAX3, MAX5, MAX6, MAX7, MAX8, MAX13, MAX14, MAX19, and MAX20) and a known local pumpkin cultivar grown in Egypt *C. moschata* “Alseiny”. Seeds of *C. maxima* accessions were obtained from the USDA, ARS North Central Regional Plant Introduction Station (NCRPIS) in Ames, Iowa. Both *C. maxima* and *C. moschata* genotypes were used as the female and male parents in reciprocal crosses. Theses interspecific hybrids were evaluated for resistance to Fusarium wilt under artificial inoculation in pot trials. Resistant hybrids were grafted onto cucumber hybrid Junco F_1 and evaluated for cucumber productivity and resistance under natural infected greenhouses with wilt diseases during 2019 and 2020 trials as indicated below. Evaluation trials were conducted in a private farm at Qallien district in Kafr El-Sheikh Governorate northern Egypt during the period from 2018 to 2020.

Disease evaluation in pot trials

Fusarium wilt strain was isolated from infected cucumber plants from Qallien district in 2018. This strain belongs to *F. oxysporum* f. sp. *cucumerinum* which was identified by morphological analysis and DNA molecular markers. The pathogen identity was supported by DNA sequences of the ITS regions (GenBank accession No. KT461496). The pathogen showed to be pathogenic to cucumber by soil inoculation, which was re-isolated from the infected plants to confirm pathogen identification.

F. oxysporum f. sp. *cucumerinum* inoculum was prepared in 500 ml glass bottles containing 100 g sorghum grains, 50 g washed sand and 80 ml tap water. The bottles were autoclaved at 121ºC for 30 min and inoculated by a 5mm disc bearing the fungal growth taken from 7-days-old culture grown on potato dextrose agar medium (PDA). The bottles were incubated for 2 weeks at 28±2ºC. Pots (25-cm diameter) were sterilized by immersing in 5% formalin solution for 15 min and then left for 2 days to insure complete formalin evaporation. Soil sterilization was accomplished with 5% formalin solution, mixed thoroughly, covered with plastic sheet for a week and then left in open air until complete formalin evaporation.

Each pot contained 3kg of sterilized soil and infested with the previously prepared inoculum at the rate of 3% and moved to plastic greenhouse (28 ± 5°C, 16/8 h day/night). Two seeds were sown in each pot and kept only one plant per pot after seed germination. Cucumber Junco F_1 hybrid was used as susceptible check. Plants were arranged according to a randomized complete block design (RCBD), with three replications and six plants per genotype in each replication (18 plants per genotype). Seedlings of interspecific rootstocks and check were kept in a greenhouse for disease evaluation. Seedlings were watered when necessary and fertilized weekly. Eighteen plants per rootstock and check without inoculation were used as negative controls.

Evaluation of disease severity was carried out on six-week-old plants according to disease symptoms on leaf, vascular discoloration and wilting using a disease rating scale (0–4) proposed by Kesevan and Chounhury (1977), where 0 = no disease symptoms (Highly Resistant “HR”), 1 = less than 25% of leaves with disease symptoms (Resistant “R”), 2 = more than 25 to 50% of the leaves showing chlorosis (Moderate “M”), 3 = more than 50 to 75% of the leaves showing chlorosis and / or stunting of some plants (Susceptible “S”), 4 = 76 to 100% chlorosis accompanied or not with both defoliation or with stunting (Highly Susceptible “HS”). Disease severity index (DSI) was calculated according to the following formula

$$\mathbf{DSI} = \frac{\sum (f \times v)}{nx} \times 100,$$

where

f = frequency of a numerical rating; v = numerical rating of the scale; n = total number of tested plants; and x = maximal value (4) of the evaluation scale.

Disease evaluation in greenhouse trials

Based on disease evaluation results from pot trials, seven resistant interspecific hybrids (A02, B02, D02, F01, G02, H01 and I02) were selected for greenhouse trials. Cucumber Junco F_1 was grafted onto seven resistant interspecific hybrids through cut grafting method (Yamakawa 1982 and Kawaide 1985). Both grafted and non-grafted cucumbers of Junco F_1 were re-evaluated under natural plastic greenhouse epidemics. Non-grafted Junco F_1 plants were used as susceptible check. Grafted seedlings along with susceptible check were transplanted in plastic greenhouse. Plants were arranged randomly in a randomized complete block design with three blocks. Ten plants per hybrid and check were used in each block. Plants spaced 1.5 × 0.5 m between and within rows. Plants were grown under drip irrigation and fertilizer was applied according Metwally and Rakha (2015). Disease severity % was recorded and calculated as indicated above after 60 days from transplanting.

Root and stem samples from infected plants were collected from plastic greenhouse and analyzed to identify soil-borne pathogens. Samples were washed with tap water to remove any adhering soil particles. Small parts of the infected tissues were surface disinfected using sodium hypochlorite solution (3.0 %) for 3 min and washed three times in sterile distilled water. Then they were dried using sterilized filter paper and transferred onto water agar medium in petri plates. Plates were incubated at 27°C for 24 to 48 hours. Hyphal tip cultures of grown fungi were maintained on Potato Dextrose Agar medium (PDA). Pathogen isolates were identified according to Booth (1971) and Sneh *et al*. (1991).

Evaluation of cucumber productivity grafted onto the interspecific hybrids

Cucumber fruits of both grafted and non-grafted plants were harvested at a marketable stage as described by Sevgican (2002). Fruit yield (number and weight [kg/m^2]) was recorded 3 times a week beginning 4 weeks after transplanting for a total of 27 harvests. Unmarketable cucumbers were excluded as those that tapered at one end or were excessively curved, which are signs of stress, disease, poor pollination or insufficient water.

Anatomical structure of grafted cucumber infected with Fusarium pathogen

Anatomical structure differences between Fusarium wilt-resistant interspecific hybrid H01 and susceptible commercial cucumber hybrid Junco F_1 were examined in the median internode of the main roots and grafting zone with plants 43 days old. Specimens were cut and fixed in a solution contained 10 ml formalin, 5 ml glacial acetic acid and 85 ml Ethyl alcohol 70%. Then, these specimens were washed in 50% ethyl alcohol, dehydrated in normal butyl alcohol series, embedded in paraffin wax of 56 ºC (melting point) and cut with a rotary microtome. Finally samples were stained with crystal violet and erythrosine, mounted in Canada balsam (Nassar and El-Sahhar, 1998). The slides were examined with a photo-microscope, and counts and measurements (µm) of the different tissues were calculated.

Statistical analysis

Statistical analyses were performed using SPSS18 software package. Disease severity and yield data were subjected to one-way analysis of variance (ANOVA) and mean comparisons were made using Duncan's multiple range test (p = 0.05). Correlation and regression coefficient "SPSS Regression Modeling" were used to determine the relationships between disease resistance parameters and fruit yield components.

RESULTS AND DISCUSSION

Results

Disease severity percentage was recorded on 6-week-old plants, and highly significant (p = 0.05) differences among interspecific hybrids were detected (Fig. 1). All susceptible check plants (Junco F_1) show severe disease symptoms with disease severity 73.4%. Mean ratings for disease severity % in the interspecific hybrids were significantly lower than susceptible check and ranged from 0 to 45%. The interspecific hybrid H01 plants show symptomless to *F. oxysporum* f. sp. *cucumerinum*. In addition, six interspecific hybrids (A02, B02, D02, F01, G02 and I02) demonstrate high levels of resistance with a mean disease severity ≤ 25%, out of the 20 interspecific hybrids evaluate, 13 were considered moderately resistant with disease severity ranged from > 25 to 45%.

To confirm the reactions of seven resistant interspecific hybrids identified in the pot trials, Junco F_1 hybrids were grafted onto these resistant hybrids and re-evaluated in plastic greenhouse. Disease severity % in seven resistant interspecific hybrids along with non-grafted Junco F_1 was recorded 60 days after transplanting, and highly significant (p = 0.05) differences among interspecific hybrids were detected (Fig. 2). Non-grafted Junco F_1 plants were susceptible with slight decrease in disease severity (64.7%) compared to first screening in pot trials. The resistant interspecific hybrid H01 plants in plastic greenhouse trial displayed again very high levels of resistance with disease severity 3.3% and resistance efficacy 94.9%. In addition, two interspecific hybrids (G02 and I02) gave a higher degree of resistance with disease severity ≤ 24.6% and resistance efficiency 61.9 and 62.9%, respectively. However, F01, D02, B02 and A02 interspecific hybrids were moderately resistant with higher disease severity (29.3 to 39.5%).

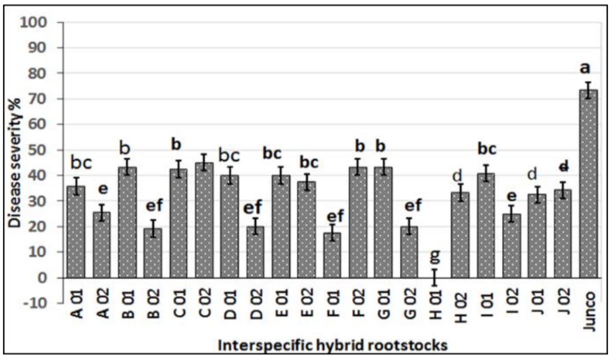

Fig. 1. Evaluation of twenty interspecific hybrid rootstocks and Junco F_1 hybrid against *Fusarium oxysporum f. sp. cucumerinum* in pot trials.

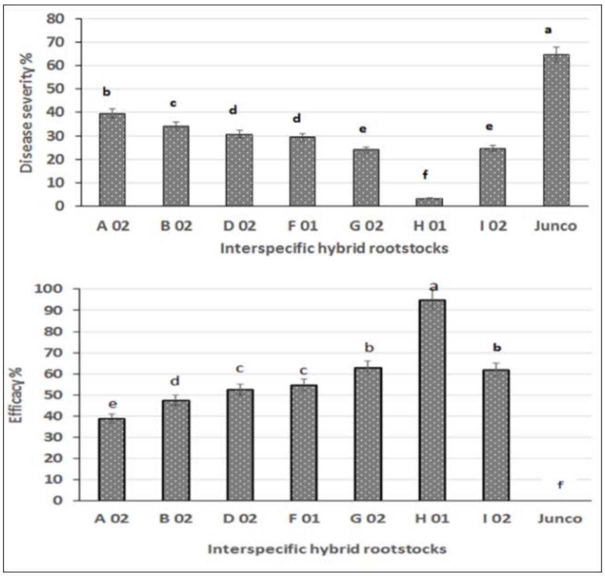

Fig. 2. Evaluation of seven interspecific hybrid rootstocks and Junco F_1 hybrid for resistance to *F. oxysporum* f. sp. *cucumerinum* in plastic greenhouse trials, data are the average of 2019 and 2020

Interestingly, four fungal species (*Fusarium oxysporum, F. solani, Rhizoctonia solani* and *Macrophomina phaseolina*) were isolated from infected roots and stems of grafted and non-grafted cucumber plants and identified according to their morphological criteria (Table 1). *Fusarium oxysporum* was the most prevalent with 46.15 % of the total counts of the isolates followed by *F. solani* and *R. solani* with frequency 23.07 and 23.07 %, respectively. However, *M. phaseolina* presented the lowest prevalent fungus with 7.7 % frequency of the total isolates.

Table 1. Frequently of the isolated fungi identified from the soil of plastic greenhouse used for evaluation of selected resistant interspecific hybrids

Isolates	No. isolates	Frequently %
Fusarium oxysporum	6.0 a	46.15
Fusarium solani	3.0 b	23.07
Rhizoctonia. solani	3.0 b	23.07
Macrophomina phasolina	1.0 c	7.70
Total	13.0	100

Values in the same column followed by the same letter are not significantly differed at P < 0.05 level.

The effects of interspecific hybrid rootstocks on total yield of commercial cucumber hybrid F1 Junco are shown in Table (2). Fruit number (14.8 to 80 /m^2) and weight (1.28 to 6.96 kg/m^2), interspecific hybrid rootstocks were significantly increased ($p < 0.05$) compared with the non-grafted Junco F_1. The highest fruit weight and number ware recorded by Junco F_1 plants grafted onto H01 interspecific hybrid with 94.56 % yield increases compared to non-grafted cucumber plants. Moreover, Junco F_1 plants grafted onto two interspecific hybrids G02 and I02 exhibited significantly higher fruit yield, being 77.71 and 78.8%, respectively, compared to non-grafted cucumber plants. On the other hand, non-grafted Junco F_1 plants recorded the lowest fruit weight and number.

Data presented in Table (3) show that diameter values of root, xylem vessels thickness, xylem thickness, phloem thickness, phloem vessels thickness and cortex's thickness were higher in resistant rootstock H01 than those in the susceptible cucumber hybrid Junco F1. Histopathology of H01 and Junco F_1 tissues infected by *F. oxysporum* f. sp. *cucumerinum* are presented in Fig. 3. Clear pathogen colonization in xylem vessels and ray parenchyma were observed in infected Junco F1 plants with *F. oxysporum* f. sp. *cucumerinum* at 43 days old (A and F). Some xylem vessels are colonized by hyphae and microconidia of the pathogen in Junco plants, which become more evident under up to 40 X magnification (Fig. 3, A, C and E). Fungal structures can also be seen due to the absence of amyloplasts in ray parenchyma cells and the significant degradation of xylem fibers, compared to tissues of intraspecific hybrid rootstock H01 (Fig. B, D and F).

Table 2. Evaluation of selected resistant interspecific hybrid rootstocks on marketable fruit yield of cucumber scion Junco F_1 in greenhouse screening trials, data are the average of 2019 and 2020.

Interspecific hybrid rootstocks	Number of fruits/ m^2	Fruit weight /m^2 (kg)	Yield increased %/m^2
A02	109.6 e	8.64 e	17.4
B02	122.4 d	9.96 d	35.32
D02	134.8 c	10.88 cd	47.82
F01	141.2 c	11.28 c	53,26
G02	158.8 b	13.08 b	77.71
H01	174.8 a	14.32 a	94.56
I02	161.2 b	13.16 b	78.8
Control (Junco F1 hybrid)	94.8 f	7.36 f	0.00

Values in the same column followed by the same letter are not significantly differed at $P < 0.05$ level.

Table 3. Means of values for the effect of the anatomical structure of roots

Genotype	Xylem thickness (µm)	Xylem vessels thickness (µm)	Phloem thickness (µm)	Phloem vessels thickness (µm)	Cortex thickness (mm)
H01	41.7 a	197.0 a	34.3 a	167.8 a	236.6 a
Junco F1	19.3 b	94.8 b	17.4 b	78.3 b	139.2 b

Values in the same column followed by the same letter are not significantly differed at $P < 0.05$ level.

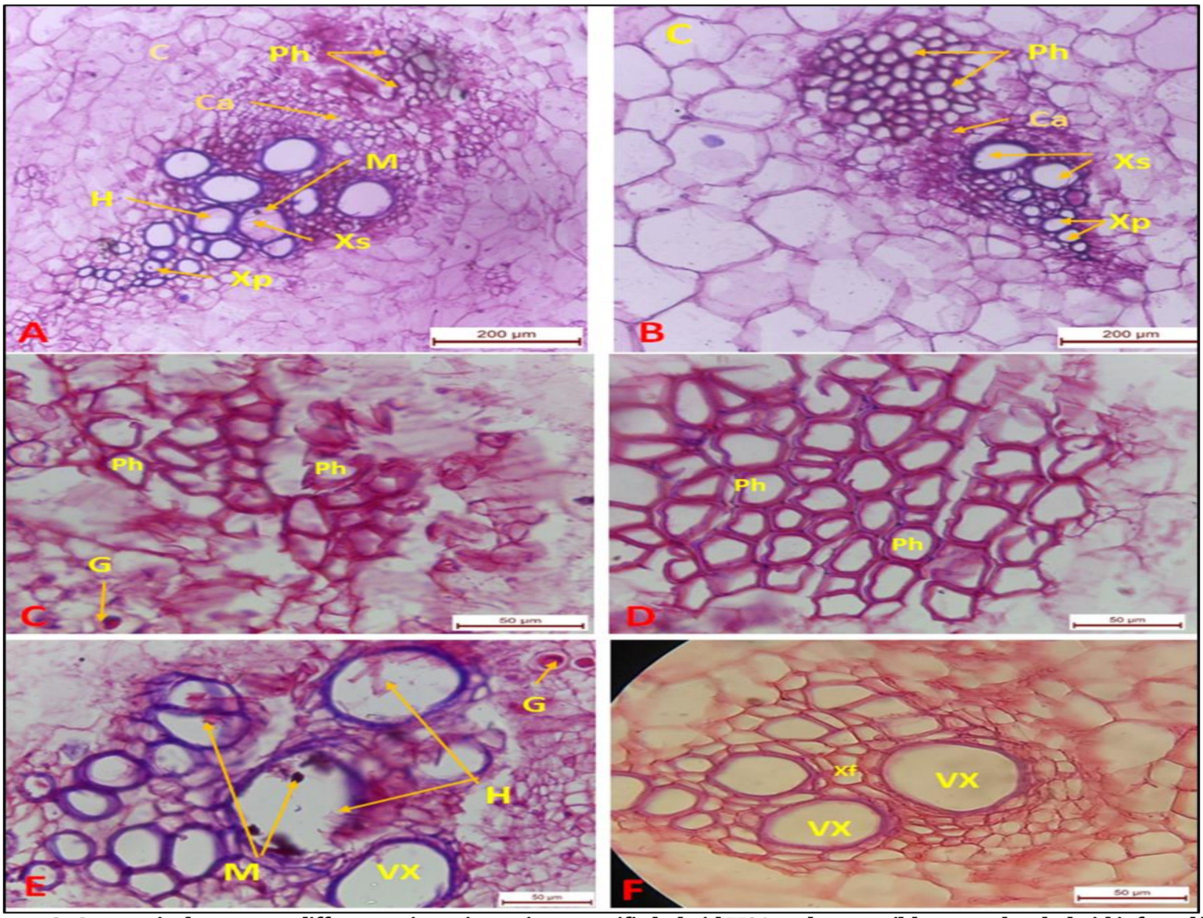

Figure 3. Anatomical structure differences in resistant interspecific hybrid H01 and susceptible cucumber hybrid infected by *F. oxysporum* on seedlings 43 days old. Cross-sections of collar root A, C and E from hybrid Junco F1, while cross-sections of collar root B, D and F from interspecific hybrid rootstock (H01). The tip of the indicator shows hyphae (E), xylem vessel occluded by microconidia (E), alterations in phloem (E). VX, xylem vessel; Xp, xylem primary; Xs, xylem secondary; Xf, xylem fibers; Ph, phloem; Ca, cambium; C, cortex; G, gel; H, hyphae of *F. oxysporum*; M, microconidia of *F. oxysporum*; A-B: 10X; C-D: 40X

The associations between disease severity and fruit yield parameters are presented in Fig. (4). Results show that there was a significant negative correlation between disease severity (%) and fruit yield parameters [efficacy of rootstock (%), number of fruits/ m^2, fruit weight /m^2 (kg) and yield increase %/m^2]. The estimated values of correlation coefficient (R^2) were 1, 0.8579, 0.8581 and 0.8581 for DS (%), efficacy of rootstock (%), number of fruits/ m^2, fruit weight /m^2 (kg) and yield increase %/m^2, respectively.

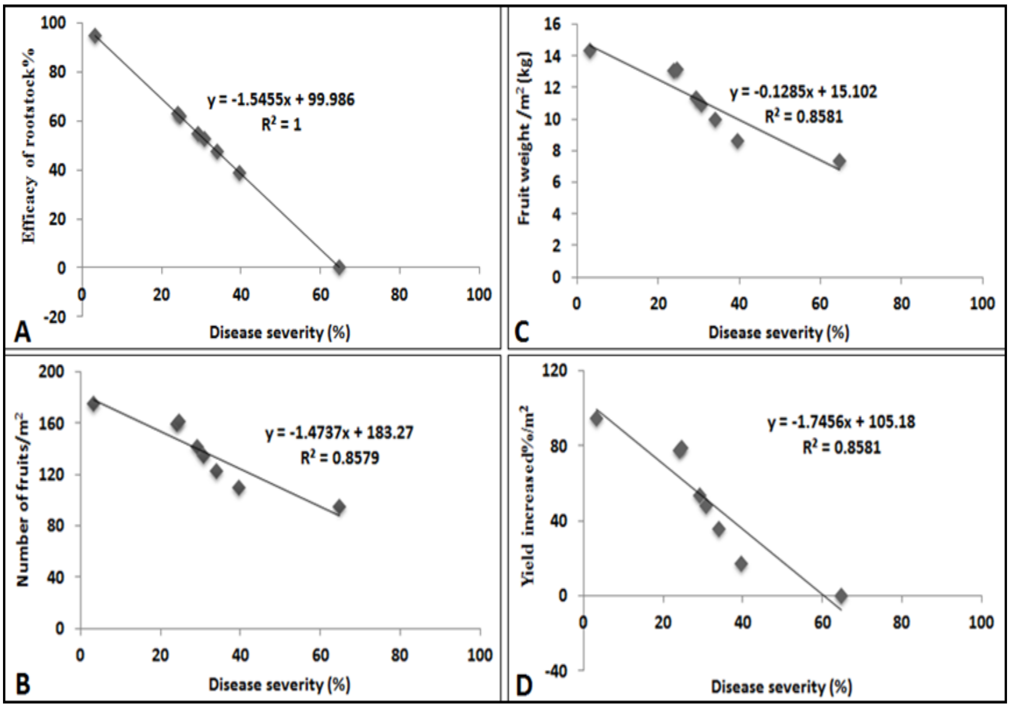

Fig. 4. Correlations between disease severity (%) and fruit yield parameters recorded in seven interspecific hybrid rootstocks.

Discussion

To date, no effective Fusarium wilt-resistant cultivars have been introduced to Egypt representing major cucurbit crops cucumber, melon and watermelon. Grafting onto Fusarium wilt-resistant pumpkin rootstocks provides as an active and safe control in these crops particularly with continuous greenhouse cropping of cucurbits. The rootstock effectiveness on disease resistance as well as productivity and fruit quality of scion is important to determine the potential utility of grafting applications (Trionfetti *et. al*., 2002). Here, twenty local interspecific hybrids between *C. moschata* and *C. maxima* were evaluated for resistance to fusarium wilt. Three of these hybrids (H01, G02 and 102) displayed very high levels of resistance against Fusarium wilt. The interspecific hybrid H01 plants (*C. maxima* × *C. moschata*) were the most resistant hybrid in both pot and greenhouse trials. These results are in agreement with those obtained by King *et al*., (2008) who reported that the most effective cucurbit rootstocks for managing *F. oxysporum* disease included interspecific hybrids of *C. moschata* and *C. maxima*. Also, as early as in 1949, Imazu (1949) recommended *C. moschata* as a rootstock, since it confers resistance to Fusarium wilt and improves plant vigor. Furthermore, Oda (1999) found that cucurbit rootstocks were effective to control other soil-borne pest southern root-knot nematode (*M. incognita*) beside Fusarium wilt fungus (*F. oxysporum*).

Four soil-borne pathogens (*Fusarium oxysporum, F. solani, Rhizoctonia solani* and *Macrophomina phaseolina*) identified in greenhouse trials, indicating interspecific hybrids identified provide resistance to a wide spectrum of soil-borne pathogens. Numerous studies have been used interspecific hybrids *C. maxima* × *C. moschata* for managing soil-borne diseases in major cucurbit crops (Yetısır *et al*. 2003a, Sakata *et al*. 2008, Bithell *et al*. 2012). This strategy has become more popular in high-value cucurbit crops to avoid soil fumigation by methyl bromide or other harmful compounds (Besri, 2008 and Bekhradi *et al*., 2011).

Disease severity % was higher in selected resistant interspecific hybrids in greenhouse trials compared to pot trials. Differences in findings between pot and greenhouse trials could be due to other soil-borne diseases identified (*F. solani, R. solani* and *M. phaseolina*) in greenhouse trials. Although mechanism of resistance or tolerance remains largely unknown, a strong and vigorous root system of rootstocks provides better tolerance against soil-borne pathogens such as *Verticillium* and *Fusarium*. Biles *et al*., (1989) found that the root system synthesizes substances resistant to pathogen attack and these are transported to the shoot through the xylem which can vary during the development stages of grafted plants (Heo, 1991).

Results of greenhouse trials indicated that fruit yield in grafted cucumbers was significantly enhanced compared to non-grafted plants of Junco F_1. These results agree with those of Yetisir and Sari (2003b) who reported that the grafting is the best agronomic interest for plant production. Also the results are in harmony with those reported by King *et al*. (2010). Moreover, grafting vegetable plants onto resistant rootstocks might enhance whole plant biotic and abiotic stress responses which lead to increase yield and fruit quality size (Rouphael *et al*., 2010). In Spain, more than

90% of watermelon plants are grafted onto interspecific hybrids (*C. maxima* x *C. moschata*) which increase yield and resistance to soil-borne diseases Singh and Mallikarjuna Rao (2014). However, grafting of cucumbers onto resistant rootstocks could lead to loss of the cucumber's taste (Yang *et al*., 2014).

Clear differences in anatomical structure between identified resistant interspecific hybrid H01 and susceptible cucumber hybrid Junco F1 were detected. The most effective mechanism of rootstock for resistance to fusarium wilt disease might include producing of antifungal compounds, forming of papillae at sites of penetration, the suberization and lignification of cell walls, the accumulation of gums, gels or tyloses and crushing within xylem cells and vessels by the proliferation of adjacent parenchymal cells (Pouralibaba *et al*. 2017). Further studies are required to investigate effect of developed rootstocks on fruit quality and taste of cucumber scions and mechanisms of tolerance or resistance to these diseases in rootstocks and grafted plants.

CONCLUSION

The development of improved cucurbit rootstocks is a daunting task because it requires a long list of desirable traits including wide adaptability to abiotic stress such as tolerance of high salinity and drought; high yields of high-quality fruit; and resistance to major soil-borne pathogens such as *Fusarium*, *Rhizoctonia*, *Verticillium*, and nematodes. Here, three interspecific hybrids of *C. maxima* x *C. moschata* exhibited very high levels of resistance against Fusarium wilt in pot trials and the results were confirmed in plastic greenhouse trials under natural epidemics with three other soil-borne pathogens (*F. solani*, *R. solani* and *M. phaseolina*). In addition, fruit yield of cucumber Junco F_1 was increased significantly from 77.7 to 94.5% when grafted onto these three hybrids compared to non-grafted plants. Further studies are required to investigate effect of developed rootstocks on fruit quality and taste of cucumber scions and mechanisms of tolerance or resistance to these diseases in rootstocks and grafted plants. The present study identified local interspecific *Cucucrbita* hybrids which could manage soil-borne diseases for major cucurbits in Egypt.

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تطعيم الخيار علي أصول الهجن النوعية للقرعيات لزيادة الانتاجية ومكافحه مرض الذبول المتسبب عن *Fusarium oxysporum* f. sp. *cucumerinum*

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تستخدم الهجن النوعية للقرعيات بصوره منتشرة كأصول لتطعيم الأصناف التجاريه لها مثل البطيخ والقاوون والخيار وذلك لزيادة الانتاجية والتغلب علي أمراض التربة. إجريت هذة الدراسة بمزرعة خاصة بمركز قلين بمحافظة كفرالشيخ في الفترة من ٢٠١٨ حتي ٢٠٢٠ لتطوير وتحديد الهجن النوعية للقرعيات المحلية المقاومة لأمراض الذبول الفيوزاريومي والتي لها توافق عالي عند التطعيم عليها مع الخيار الهجين. أظهرت النتائج انخفاض معدل الاصابة للذبول (صفر الي ٤٠%) معنويا في أصول الهجن النوعية عن الصنف القياسي الجانكو تحت ظروف العدوي الصناعية بتجربة الاصص. أظهرت النتائج سبعة أصول من العشرون هجين مقاومة عالية للذبول بمعدل اصابة أقل من او يساوى ٢٥%. أكدت نتائج تقييم الاصول تحت ظروف العدوي الطبيعية بالصوب البلاستيكية وجود مقاومة عالية بثلاث هجن نوعية (G02, H01 , I02). وكانت هناك زيادة معنوية في صفات المحصول للخيار المطعم جانكو مقارنة بالنباتات الغير مطعومة. كما كانت هناك اختلافات تشريحية واضحة بين الأصل المقاوم وهجن الخيار جانكو. وكان هناك ارتباط سلبي معنوى ملحوظ بين صفات المحصول للخيار ومعدل الاصابة للذبول. ويتضح من هذة الدراسة أن الهجن النوعية للقرعيات التي تم إنتاجها محليا هي واعدة لإستخدامها كأصول للتطعيم عليها لزيادة المحصول والتغلب علي أمراض التربة في الانتاج التجاري للقرعيات بمصر.