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Rootstock effects on nematode resistance, growth and yield of greenhouse cucumber

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Abstract

Experiments with cucumbers (variety Kiara) grafted onto different cucurbit rootstocks were carried out to study their susceptibility to the root-knot nematode *Meloidogyne incognita*. The study was conducted in an unheated glasshouse at the Maritsa Vegetable Crops Research Institute, Plovdiv under an artificial nematode infestation. The growth and productive manifestations of the grafted plants were reported. The lowest root gall index was reported for CM720xNY and CM720xAphrodita, 0.6 and 0.8, respectively. Cucumbers grafted onto CM720xNY rootstock showed the best productive qualities and realized the highest quantities first and second quality produce (34880 kg/ha and 29320 kg/ha, respectively) and total yield (64210 kg/ha). The cucumber grafted onto CM720xCarotina rootstock showed the lowest productivity - 13540 kg/ha first quality, 15460 kg/ha second quality and a total yield of 29000 kg/ha. Relatively the best biometric parameters were established in cucmber grafted onto CM720xAphrodita and CM720xNY rootstocks.

Keywords: cucumber, grafting, *Meloidogyne incognita*, biometrical parameters

INTRODUCTION

Cucumber (*Cucumis sativus* L.) is one of the most widespread vegetable crops in cultivation facilities with cucumber occupying the second place in economic importance in greenhouse production in Bulgaria (Velkov & Pevicharova, 2016). Greenhouse production ensures a year-round supply of fresh vegetables to the market. The economic importance of greenhouse vegetable production is related to the fact that higher incomes can be obtained through it. However, intensive and monoculture cultivation of cucumbers in greenhouses favors the development and multiplication of plant-parasitic nematodes and soil-borne pathogens (Oda 1999; 2002).

Root-knot nematodes of the genus *Meloidogyne* are considered the most important plant-parasitic nematodes on cucumber. They cause yellowing of leaves, stunted plant growth, reduced fruit size, low yield, severe root gall formation, root rot and reduced root system (Punithaveni et al., 2015). Their presence in the soil can alter water and nutrient uptake, inhibit photosynthesis, and increase the incidence of *Fusarium oxysporum* f. sp.*radicis-cucumerinum* (Ismail et al., 2012). The extent of damage caused depends on nematode population density, crop sensitivity, and environmental conditions such as fertility, moisture, and presence of other pathogenic organisms that may interact with nematodes (Tamil Selvi et al., 2013).

Traditionally, control with root-knot nematodes is carried out mainly with chemical plant protection products. The use of nematicides only offers a temporary solution and has no lasting effect on nematode populations. In addition, for environmental and toxicological reasons, the number of authorized nematicides is drastically reduced. The worldwide trend for a clean agricultural

production and environment minimizes the use of pesticides (Atkins et al., 2005).

Grafting onto resistant rootstocks is a commonly recommended technique for cucumbers in areas infested with root-knot nematodes (Salata, et al., 2012). Cucumber cultivars resistant to one or more root-knot nematode species would benefit growers by providing the necessary control with reduced nematicide use (Walters et al., 1993). The grafting crops of the Cucurbitaceae is a technologically proven approach for the prevention of plants from soil-borne pathogens and nematodes (Lee et al., 2010). Grafting has a positive effect on plants, which is expressed by increasing growth manifestations, early maturity, yield and tolerance to stress factors (Huang et al., 2009; Cansev & Ozgur, 2010). Due to the recognized benefits, the grafting of cucumbers onto resistant rootstocks of the Cucurbitaceae family has increased steadily in the recent years (Lee et al., 2010).

The aim of this study was to evaluate the response of cucumbers grafted onto cucurbit rootstocks to root-knot nematode infestation and to record plant growth and productivity.

MATERIALS AND METHODS

The experimental work was carried out in an unheated glass greenhouse at Maritsa Vegetable Crops Research Institute, Plovdiv during the period 2019-2021.

Grafted plants and nematode inoculum

Cucumber variety Kiara was grafted onto the rootstocks CM720xAphrodita, CM720xNY, TG and CM720xCarotina. Cucumber variety Kiara was used as an ungrafted control.

A pure culture of root-knot nematode *Meloidogyne incognita* was maintained on susceptible tomato plants under pot conditions. The egg masses were obtained from heavily infected tomato roots using a 0.5% NaOCl solution according to Hussey & Barker (1973). *Meloidogyne incognita* second-stage juveniles (J2) were obtained using a modified Baermann using a modified Baermann tray (Whitehead & Hemming, 1965). The second-stage infective juveniles were counted under a stereomicroscope with the help of a counting dish and used for inoculation.

Grafted plants were transplanted in plastic pots containing sterilized mixture (peat:perlite:sand in 1:1:1 ratio) for artificial inoculation of *M. incognita*. Each plant was inoculated with 2 J2/g soil.

Root gall index was recorded on 0-4 scale, where 0 - no infection; 1 - weak infestation (1% - 25%), 2 - medium infestation (26% - 50%), 3 - strong infestation (51% - 75%), 4 - very strong infestation 76% - 100% roots with galls (Barker, 1985).

The following growth parameters were recorded: plant lenght (cm), stem diameter (mm), root length (cm), root weight (g). The first and second quality produce and the total yield harvested was recorded three times a week (Monday, Wednesday and Friday).

Statistical analysis

Data were processed using Duncan's multiple range test at $P < 0.05$ levels (Duncan, 1955).

RESULTS AND DISCUSSION

Among the tested grafted cucumber to their attack by the root-knot nematode *M. incognita*, the lowest root gall index was recorded for CM720xNY and CM720xAphrodita, 0.6 and 0.8 respectively. A low degree of infection was found for the other two rootstocks TG (1.3) and CM720xCarotina (1.7). The ungrafted control showed the highest gall index of 3.4 (Fig. 1).

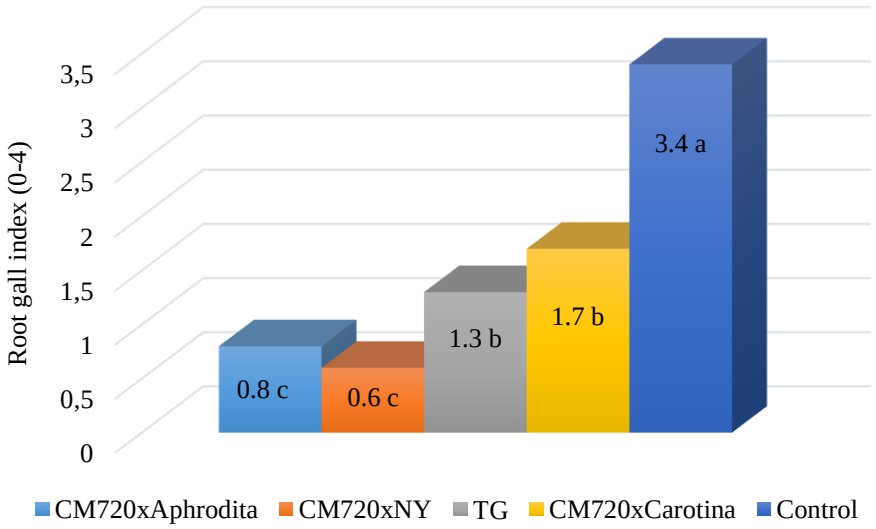

Figure 1. Root gall index in cucumbers variety Kiara grafted onto different cucurbit rootstocks

Table 1. Growth parameters of cucumber variety Kiara grafted on different cucurbit rootstocks

Variant	Plant length, cm	Stem diameter, mm	Weight of aboveground part, g	Root length, cm	Root weight, g
CM720xAphrodita	198^{ab}	12.17^{a}	286.67^{ab}	39.68^{ab}	80.22^{ab}
CM720xNY	202^{ab}	12.52 ^{a}	263.46^{ab}	37.33^{ab}	123.31^{a}
TG	211^{ab}	12.77 ^{a}	363.34^{a}	37.82^{ab}	75.20^{ab}
CM720xCarotina	239^{a}	11.67 ^{ab}	230.21^{b}	43.56^{a}	95.65^{ab}
Control	173^{b}	9.61 ^{b}	251.00^{ab}	32.12^{b}	62.12^{b}

Legend: a, b, c … – Duncan's multiple range test ($p < 0.05$)

The greatest plant length was recorded in cucumber variety Kiara grafted onto the CM720xCarotina rootstock (239 cm). The greatest weight of the aboveground part was observed when cucumber was grafted onto the TG rootstock (363.34 g), followed by CM720xAphrodita (286.67 g) and CM720xNY (263.46 g). The greatest root length was recorded in CM720xCarotina (43.56 cm), and the greatest root weight in CM720xNY (123.31 g) (Table 1).

The cucumber grafted onto CM720xNY rootstock significantly outperformed the other variants by forming the highest quantity of first quality produce - 34880 kg/ha. The values of this indicator in the other variants ranged from 13540 kg/ha (CM720xCarotina) to 27490 kg/ha (TG), and the differences are mathematically proven (Fig. 2).

Cucumber grafted onto TG (28730 kg/ha) and CM720xNY (2932 kg/ha) formed a significantly higher quantity of second quality produce compared to the other variants. With proven lowest values for this indicator was recorded in the Control - 11450 kg/ha (Fig. 2).

The statistical analysis divided the results determining the total yield into five groups of evidence. In the first one, the cucumber grafted onto CM720xNY rootstock obtained the highest values - 29320 kg/ha. The total yield varied with the type of rootstock and ranged from 29000 kg/ha (CM720xCarotina) to 56210 kg/ha (TG).

From the results obtained, it can be concluded that all the rootstocks tested had positive effect on productive performance, which is in confirmation of Hoyos (2001) who

found that grafting cucumber on rootstocks reduced the rate of growth, but the total yield increased compared to the non-grafted variants. The exception are the cucumber plants grafted onto CM720xCarotina rootstock, which register the weakest productive qualities. According to Moradipour et al. (2010), the type of rootstock has a significant effect on the growth and productive qualities of the plant.

Regarding the indicator of the average fruit weight of first quality, it was found that the rootstock CM720xNY (0.269 kg) had a significantly lower value compared to the other rootstocks, where the weight ranged from 0.290 kg (CM720xAphrodita) to 0.304 kg (TG). No significant differences were found in the average fruit weight of second quality, which ranged from 0.281 kg in CM720xNY to 0.306 kg in Control (Table 2) .

Similarly to the results obtained for the average fruit mass of the first quality, cucumbers grafted on the CM720xNY rootstock (0.274 kg) formed fruits with an overall average mass significantly lower than the other variants, with values as high as 0.296 kg on the TG rootstock (Table 2). These results do not confirm the data obtained by Passam et al. (2005) and Pogonyi et al. (2005), who found that grafting had a positive effect by increasing fruit size in tomato and eggplant.

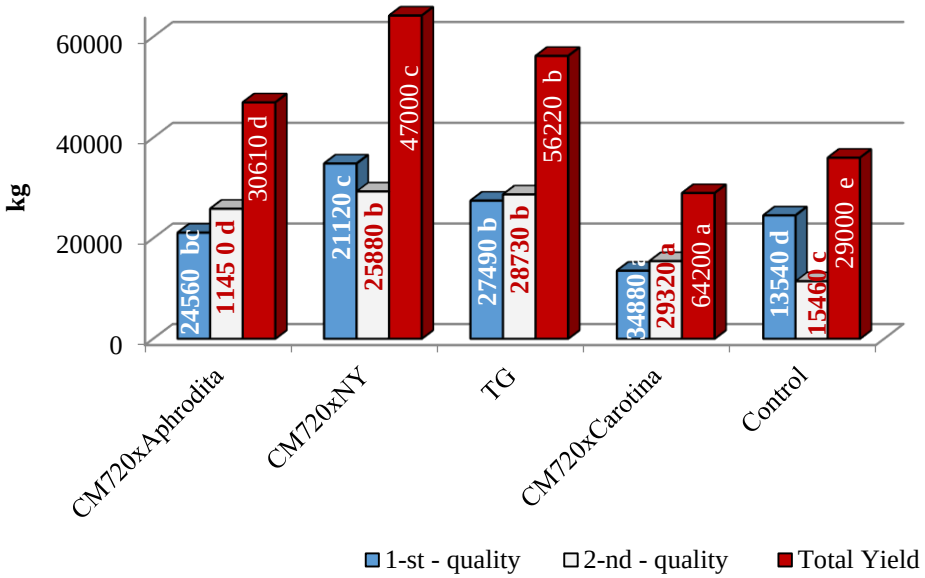

Figure 2. Distribution of yield by produce quality in cucumber variety Kiara grafted onto different cucurbit rootstock

Table 2. Average fruit weight by quality in cucumber variety Kiara grafted onto different cucurbit rootstock

Variant	1-st quality kg	Sig.	2-nd quality kg	Sig.	Total yield kg	Sig.
CM720xAphrodita	0.290	a	0.301	n.s.	0.295	a
CM720xNY	0.269	b	0.281	n.s.	0.274	b
TG	0.304	a	0.291	n.s.	0.296	a
CM720xCarotina	0.302	a	0.286	n.s.	0.292	a
Control	0.290	a	0.306	n.s.	0.292	a

Legend: a, b, c … – Duncan's multiple range test ($p < 0.05$); n. s. – none significant

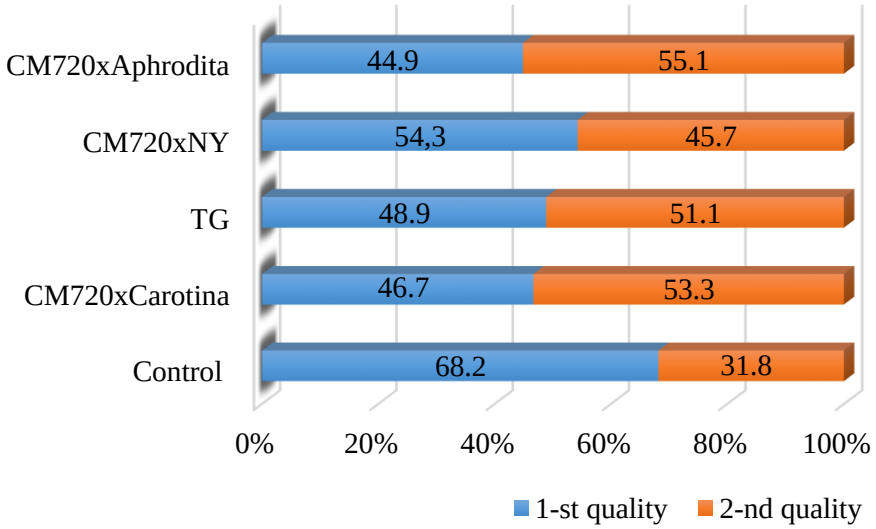

Figure 3. Percentage distribution of produce by quality relative to total yield in greenhouse cucumbers

Determining the percentage of first quality produce relative to total yield, it can be concluded that apart from the Control, which formed the largest proportion of first quality produce (68.2%), the percentage of first quality yield was higher in cucumber grafted onto CM720xNY rootstock (54.3%). In the other variants, the yield of second quality was higher, and this was most pronounced in the cucumber grafted onto the CM720xAphrodita rootstock, where the proportion of first quality produce was only 44.9% (Fig. 3).

CONCLUSIONS

The lowest infestation by *Meloidogyne incognita* was found in cucumber grafted onto CM720xNY rootstock. Cucumber grafted onto this rootstock exhibited the best productive qualities and realized the highest quantities of first and second produce, and total yield.

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