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Performance of cucumber hybrids cultivated in coconut fiber and soil

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ABSTRACT

The objective of this work was to evaluate the performance of three Japanese group cucumber hybrids, which were cultivated in two cultivation systems. The experiment was designed in a split-plot randomized block design with two cultivation systems (coconut fiber and soil) for commercial Japanese cucumber hybrids (‘Tsuyataro’, ‘Yoshinari’ and ‘Nankyoku’). After harvesting the cucumbers, we evaluated the number of marketable fruits per plant, the average fruit length, the mean fruit diameter, the bottom fruit diameter, the marketable production of fruits per plant and the marketable yield per hectare. There were significant interactions between the cultivation system and the hybrid, as indicated by the number of marketable fruits. The Nankyoku hybrid had the highest average (14.54 fruits pl^{-1}), although it did not differ from the Yoshinari hybrid when grown in coconut fiber. In soil culture, the Yoshinari hybrid had the highest average number of fruits per plant (10.12 fruits pl^{-1}) and did not differ from the Tsuyataro hybrid. Cultivation in coconut fiber provided better results for production traits and plant productivity. ‘Yoshinari’ and ‘Nankyoku’ were the most productive hybrids. Based on the cucumber cultivation results from a protected environment, the cultivation of hybrid Japanese cucumbers and Yoshinari and Nankyoku hybrids in coconut fiber is recommended.

Keywords: *Cucumis sativus*, protected cultivation, substrate.

RESUMO

Desempenho de híbridos de pepino cultivados em fibra de côco e solo

O objetivo deste trabalho foi avaliar o desempenho de três híbridos de pepineiro, do grupo japonês, cultivados em dois sistemas de cultivo. O delineamento experimental adotado foi em blocos casualizados, em esquema de parcelas subdivididas, sendo considerados como parcela principal, dois sistemas de cultivo (fibra da casca de coco e solo) e nas subparcelas, três híbridos comerciais de pepineiro japonês (‘Tsuyataro’, ‘Yoshinari’ e ‘Nankyoku’). Após a colheita foram avaliados: número de frutos comerciais por planta; comprimento médio do fruto; diâmetro superior do fruto; diâmetro médio do fruto; diâmetro inferior do fruto; produção comercial de frutos por planta; e produtividade comercial por hectare. Houve interação significativa entre sistemas de cultivo e híbridos apenas para a característica de número de frutos comerciais. O híbrido Nankyoku apresentou a maior média (14,54 frutos pl^{-1}), embora não tenha diferido do híbrido Yoshinari, quando cultivados em fibra da casca de coco. No cultivo em solo, o hibrido Yoshinari apresentou a maior média de frutos por planta (10,12 frutos pl^{-1}), não diferindo do híbrido Tsuyataro. O cultivo em fibra de coco proporcionou melhores resultados para as características de produção por planta e produtividade. Entre os híbridos avaliados, ‘Yoshinari’ e ‘Nankyoku’ foram os mais produtivos. Com base nos resultados obtidos, para o cultivo de pepino sob ambiente protegido, recomenda-se o cultivo dos híbridos de pepino japonês Yoshinari e Nankyoku em fibra da casca de coco.

Palavras-chave: *Cucumis sativus*, cultivo protegido, substrato.

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The cucumber (*Cucumis sativus*) has great economic and social importance among the vegetables grown by Brazilian agribusiness. Cucumbers are greatly desired and consumed in all regions. Furthermore, they can be used in cosmetics and medicines because of their nutraceutical properties (Carvalho *et al*., 2013).

Data from Embrapa (2010) show that the annual Brazilian cucumber output exceeds 200,000 tons. The southeastern region accounts for over 50% of total Brazilian cucumber production (Carvalho *et al*., 2013).

A considerable number of cucumber farmers cultivate their products in soil, covered areas or in greenhouses. However, there have been significant advances in the amount of productive units grown in containers of various substrates, which require practical considerations relating to biocide expenses, improved product quality, the standard of plants produced and the result of these changes in the marketing of the final product (Kämpf, 2002).

However, the intensive use of land in a protected environment has caused salinization and pathogen problems. Thus, preventative measures to avoid degradation have been used in the cultivation substrates. These culture systems promote increases in productivity and fruit quality, greater density, and reductions in the use of pesticides, enabling the production of healthier fruits (Melo *et al*., 2012).

The development of cultivation

substrates, such as coconut fiber, have yielded improvements because of the advantages that this substrate imparts, such as adequate water management, appropriate nutrient doses and times, and reduced root medium salinity and pesticide problems, which translate into direct benefits for the yield and quality of harvested products (Charlo *et al*., 2009).

According to some authors (Vargas *et al*., 2008; Charlo *et al*., 2009; Melo *et al*., 2012), recent studies have confirmed improvement sin fruit quality as well as higher yields of growing crops in coconut fiber in a protected environment. However, according to Fernandes *et al*. (2006), there has been a gradual replacement of soil by cultivation substrates, which are used for the optimization of productivity, uniformity and fruit quality.

Studies comparing production systems to cucumber soil substrate cultivation are scarce. Hence, the present study aimed to evaluate the production of Japanese cucumber hybrids grown in coconut fiber as well as soil under greenhouse conditions.

MATERIAL AND METHODS

This study was performed at the College of Agricultural and Veterinary Sciences (UNESP-FCAV) (21°14'05"S, 48°17'09"W, altitude of 614 m), campus in Jaboticabal, São Paulo state, Brazil, from June 10 to October 05.

The adopted experimental design was a split-plot arrangement; primary plots consisted of cultivation systems (substrate and soil), and subplots consisted of the Japanese cucumber hybrids (Tsuyataro, Yoshinari and Nankyoku), with four replications. Each plot was composed of six plants, but only the four middle plants were evaluated.

The characteristics of the selected hybrids were: Tsuyataro [Japanese hybrid type, medium cycle, high uniformity and excellent quality of fruits, easy to grow, low bud sprouting and resistance to downy mildew and powdery mildew, high quality of fruits throughout harvest (Takii seed, 2013)]; Yoshinari [Japanese hybrid group, dark green and glossy fruits, industry standard (Sakata Seed, 2013)]; and Nankyoku [Japanese hybrid group, imported from Japan; no description was available from the company].

The greenhouse had an arc-like structure that was 50 m in length and 12 m wide, with 3.5 m ceilings that were covered with low density polyethylene film with a thickness of 150 microns and black-screened sides that provided 50% shade.

Plantmax Hortaliças HT substrate was used for the sowing stage and was placed in polystyrene trays of 128 cells, with one seed per cell. After sowing, the trays were settled under protection and irrigated three to four times per day. Seedling transplantation to the final location was carried out when the first definitive leaf was completely expanded.

A chemical analysis from the experimental soil cultivation system was performed at UNESP-FCAV and yielded the following characteristics: pH= 4.8; OM= 21 g dm^{-3}; P= 73 mg dm^{-3}; K= 4.0 $mmol_c$ dm^{-3}; Ca= 26.0 $mmol_c$ dm^{-3}; Mg= 12 $mmol_c$ dm^{-3}; H+Al= 52 $mmol_c$ dm^{-3}; SB= 42 $mmol_c$ dm^{-3}; CEC= 94 $mmol_c$ dm^{-3}; and V% 45. Fertilization was carried out according to the soil analysis, with 40 kg ha^{-1} N, 100 kg ha^{-1} K_2O and 200 kg ha^{-1} P_2O_5 (Raij *et al.*, 1997). Three topdressing fertilizations were performed; the first occurred 15 days after seedling transplant, and the other fertilizations occurred after 15-day intervals, with125 kg ha^{-1} N and 90 kg ha^{-1} K_2O.

Cultivation in coconut fiber was carried out in plastic pots with 31.3 cm and 22.1 cm diameters at the top and bottom, respectively, 27.5 cm height and a total capacity of 13 L, and they were filled with the commercial substrate, Mix Golden® joint 98, which is prepared from coconut mesocarp by using the granular fibrous portion. This substrate has the physical characteristics: porosity of 95% and a water retention capacity of 400 mL per liter of substrate (Amafibra, 2013).

A chemical analysis of the substrate was performed by using the 1:1.5 v:v extraction method as suggested by Sonneveld & Elderen (1994), and the following characteristics were determined: pH= 6.35; electrical conductivity = 0.15 dS m^{-1}; $N\text{-}NH_4^+$= 2.026 mg L^{-1}; $N\text{-}NO_3^-$= 3.076 mg L^{-1}; P= 0.802 mg L^{-1}; K= 27.586 mg L^{-1}; Ca= 2.931 mg L^{-1}; MG= 0.928 mg L^{-1}; S= 1.893 mg L^{-1}; B= 0.117 mg L^{-1}; Cu= 0.016 mg L^{-1}; Fe= 0.872 mg L^{-1}; Mn= 0.019 mg L^{-1} and Zn= 0.008 mg L^{-1}.

For the soil cultivation system, drip irrigation was performed according to the crop developmental stage and need. For the substrate cultivation system, drip irrigation was combined with a nutrient solution, as recommended by Castellane & Araújo (1994) for hydroponic cucumber cultivation. The macro and micronutrient recommendations for 1.000 L were: 240 g magnesium sulfate, 155 g monoamonic phosphite, 805 g calcium nitrate, 277 g potassium nitrate, 238 g potassium chloride, 36 g DTPA iron, 1.8 g boric acid, 2.54 g manganese sulfate, 1.15 g zinc sulfate, 0.12 g copper sulfate, and 0.12 g sodium molybdate. Fertigation was automatically controlled by a timer from 7 a.m. to 6 p.m., and input was determined with respect to the plant age and pot drainage.

The rational control of both pests and diseases was performed by visually examining the agent, insect or pathogen and using chemicals that were registered for the culture according to technical recommendations.

In both systems, there was one plant per pot or planting hole, and staking was performed by using a plastic tape of up to 2.2 m height from the soil level, at which the main stem was trimmed. The plants were grown with one main stem, and the side branches were removed up to the fifth main stem bud. The apical buds of the side branches were also pruned so that only three leaves per side branch remained.

Fruits were harvested weekly after reaching commercial size, which led to a total of 14 samples at the end of the cycle. For the evaluation, fruits were separated into commercial and non-commercial grades, and the latter group was discarded. Unmarketable fruits were those that presented tortuous shapes exhibiting rot, fine tips and any deformations, according to Carvalho *et* *al*. (2013).

We evaluated the variables: the number of marketable fruits (NFC), namely the amount of marketable fruits per plant throughout the cycle; the fruit length (COMP, cm), in which the lengths of the fruits were assessed during harvest by digital caliper; the largest diameter of the fruits (DSF, cm), as measured by taking the diameter of the region near the stalk of the fruits by digital caliper; the fruits mean diameter (DMF, cm) as measured from the middle region of the fruits and evaluated during the crop cycle by digital pachymeter, the lowest diameter of the fruits (DIF, cm) by measuring the diameter of the region opposite to the stalk by digital pachymeter; the commercial production of fruits (PCF, kg plant^{-1}) corresponding to the sum of the mass of commercial fruits produced per plant during the whole crop cycle, as measured with a digital scale; and productivity (Y, t ha^{-1}), or the estimated mass of marketable fruits per hectare during the crop cycle.

The data were submitted to an analysis of variance by the F test, and the means were compared by Tukey's test at 5% probability using the AgroEstat Software (System of Statistical Analysis for Agronomic Experiments) version 1.0.

RESULTS AND DISCUSSION

According to the analysis of variance, there was a significant interaction between cropping systems and hybrids for the characteristic number of marketable fruits (Table 1). There were no significant interactions between the evaluated factors for the other characteristics, which are presented separately.

For the characteristic numbers of commercial fruits under coconut fiber cultivation, we observed a higher average for the Nankyoku hybrid (14.54 fruits pl^{-1}) that did not statistically differ from the Yoshinari hybrid (13.50 fruits pl^{-1}), which represented 47% and 25%, respectively, compared to the hybrids cultivated in soil. In the soil culture, the Yoshinari hybrid had the highest number of fruits per plant, with an average of 10.12 fruits, which did not differ from the Tsuyataro hybrid. The number of fruits per plant was higher regardless of the hybrid when the cultures were grown in coconut fibers (Figure 1), most likely because of the better soil conditions of this system, which produced hybrids that were more productive.

The amount of marketable fruits produced by plants is related to both the genotype and cultivation environment, and in both cases, the production of female flowers is a major feature that determines this factor (Rudich *et al*., 1972). In this research, coconut fiber enhanced cucumber growth, which was combined with a regular supply of nutrients to assure good nutrition and a consequently uniform product.

It appears that there were no significant differences between the average cropping system factors (coconut fiber and soil) and hybrids (Tsuyataro, Yoshinari and Nankyoku) for the characteristic length of fruits, with a mean of 24.03 cm. Cardoso (2007) evaluated experimental lines and hybrids of cultured Japanese cucumbers and found 21.7 and 23.5 cm for 'Tsuyataro' and 'Yoshinari', respectively. The differences obtained in this study may have occurred in response to a sampling point difference because the fruits of this labor were harvested when they reached the visual characteristics desired by the market. Despite these differences, the fruit from both studies were within the standards recommended by Filgueira (2007) for Japanese cucumbers (20-30 cm).

In analyzing the larger diameter of the fruits, a difference was observed only for the hybrid factor, with the highest averages obtained for 'Yoshinari' and 'Nankyoku' at 34.46 and 3.53 cm, respectively. For the average fruit diameter, there was only a significant difference for the hybrid factor, with 'Nankyoku' yielding a greater diameter than the other hybrids (3.54 cm). As for

Table 1. Mean values for the number of marketable fruits per plant(NFC), length (COMP), larger diameter (DSF), average diameter (MFD), bottom diameter of fruit (DIF), marketable fruit yield (PFC) and productivity (Y) [valores médios para número de frutos comerciais por planta (NFC), comprimento (COMP), diâmetro maior (DSF), diâmetro médio (MFD), diâmetro menor dos frutos (DIF), produção de frutos comerciais (PFC) e produtividade (Y)]. Jaboticabal, UNESP, 2009.

System (S)	NFC	COMP (cm)	DSF (cm)	DMF (cm)	DIF (cm)	PFC (kg/pl)	Y (t/ha)
Coconut fiber	13.25 a	23.87 a	3.29 a	3.27 a	2.84 a	2.42 a	48.44 a
Soil	8.90 b	24.19 a	3.49 a	3.47 a	2.88 a	1.81 b	36.36 b
Hybrid (H)							
Tsuyataro	10.32 a	25.01 a	3.10 b	3.19 b	2.76 a	1.90 b	38.00 b
Yoshinari	11.81 a	23.68 a	3.45 a	3.37 ab	2.84 a	2.27 a	45.51 a
Nankyoku	11.09 a	23.41 a	3.53 a	3.54 a	2.94 a	2.18 ab	43.68 ab
Average	11.07	24.03	3.36	3.37	2.86	2.12	42.39
Interaction S x H	6.44 *	2.21 ns	2.58 ns	0.76 ns	0.57 ns	2.58 ns	0.35 ns
CV (%) (plot)	11.97	5.91	11.89	4.82	2.25	11.89	6.36
CV (%) (subplot)	11.17	5.59	10.59	6.06	6.45	10.59	5.32

*Means followed by the same letter do not differ from each other according to Tukey's test at a 5% probability; ns: nonsignificant (médias seguidas de letras iguais não diferem entre si, pelo teste de Tukey a 5% de probabilidade; ns: não significativo).

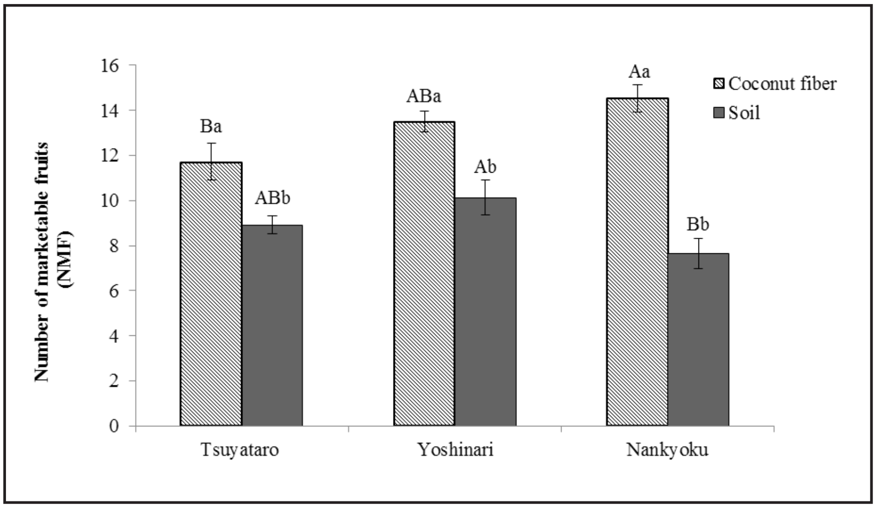

Figure 1. Number of marketable fruits per plant (NMF) for cucumbers cultivated in coconut fiber and soil; means followed by the same uppercase letter (hybrid), and lowercase letter (cultivation system) do not differ according to Tukey's test ($p>0.05$) [número de frutos comerciais por planta (NMF) de pepino cultivado em fibra de côco e solo; medias seguidas pela mesma letra maiúscula (híbrido) e minúscula (sistema de cultivo) não diferem de acordo com o teste de Tukey a 5%]. Jaboticabal, UNESP, 2009.

the lower average diameter, there were no differences between the cultivation system and hybrids, with an average of 2.86 cm (Table 1).

Cardoso (2007) obtained 2.97 and 2.99 cm for Japanese cucumber hybrids 'Tsuyataro' and 'Yoshinari' in a protected environment. Lima & Cardoso (2012) obtained 2.65 and 2.69 cm for 'Tsuyataro' and 'Yoshinari' in a protected environment. These results confirmed that these are intrinsic characteristics of each hybrid, which were coupled with standardized sampling points in which the average diameter of Japanese commercial cucumbers is up to 3 cm (Lima & Cardoso, 2012).

Thus, the length and diameter results assessed in this study demonstrate that these biometric characteristics are specific to each hybrid, and choices of shape and length must be made in accordance with the consumer market.

Significant differences between cultivation systems and the hybrid were found when analyzing plant production characteristics (Table 1). For the cultivation system, the best performances were obtained for coconut fiber (2.42 kg pl^{-1}).For the hybrid factor, the best performance was obtained from 'Yoshinari' at 2.27 kg pl^{-1}, followed by 'Nankyoku' at 2.18 kg pl^{-1}.

In the literature, there are similar results for cucumber production in different substrates. Costa *et al*. (2009) evaluated substrates using the Hyuma hybrid, and they observed that cultivation in coconut fiber yielded an average of 2.22 kg $plant^{-1}$, and soil cultivation yielded an average of 2.42 kg $plant^{-1}$. Cardoso & Silva (2003) found 3.79 kg $plant^{-1}$ for Tsuyataro hybrids in soil culture. Souza *et al*. (2005) found 3.07 kg $plant^{-1}$for the cultivation of 'Hokuho' in coconut fiber.

According to Vargas *et al*. (2008) and Charlo *et al*. (2009), the higher yields from coconut fiber cultivation was explained by good plant nutrition because fertilizers were administered in divided doses and were readily available to plants, resulting in a higher effect, with consequently lower abiotic factor interference.

For estimated commercial yields, it is possible to observe that there were differences between cultivation systems and the hybrid (Table 1). For the cultivation system, the best performances were observed for coconut fiber cultivation (48.44 t ha^{-1}). For the hybrid factor, the best performance was observed in 'Yoshinari' with 45.51 t ha^{-1}, although this performance did not differ from that of 'Nankyoku', which had a productivity of 43.68 t ha^{-1}.

According to Charlo *et al*. (2009), the cropping system performance in coconut fiber is explained by the use of fertigation, which promotes increased productivity and fruit quality, providing appropriate amounts of nutrients to the plants for each stage of crop development and reducing the incidence of pests. Furthermore, these results demonstrate that coconut fiber performs well as a substrate for growing vegetables under favorable environmental conditions, and it is a renewable raw material with low costs for the producer (Carrijo *et al*., 2004).

Under the conditions in which the experiment was conducted, coconut fiber cultivation provided better expression of the evaluated characteristics, with the Yoshinari hybrid presenting better performance; therefore, cultivating cucumbers in coconut fiber with fertigation in a protected environment is recommended.

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