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Effect of different rooting media on growth and yield performances of carrot (*Daucus carota*)

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Abstract

Field experiment was conducted to assess effect of different rooting media on growth and yield performance of carrot (*Daucus carota)*. The experiment was conducted at Faculty of Agriculture, Ariviyal Nagar, Kilinochchi from March to June2017. Two factor factorial experiment was carried out in Complete Randomized Design (CRD) with four replicates. Four rooting media treatments (Coir dust, leaf mould, compost and top soil)and two varieties (Kimona and New Kuroda)were used in this experiment. Weather, growth, yield parameters were recorded and data were analyzed in ANOVA using SAS 9.1 package. The means were compared by using Duncan Multiple Range test. All other management practices were performed based on the recommendation made by the Department of Agriculture. Leaf number, leaf length, canopy diameter, root length, root circumference and yield were significantly differed among the rooting medium. There was no significant difference in leaf number, leaf length, canopy diameter, root length, root circumference and yield in both carrot varieties. Growth and yield parameters were well performed in coir dust containing medium and top soil (control) gave the lowest performance of both growth and yield parameters, due to difference in root penetration and growth. But there was no significant difference between coir dust and compost containing medium. It can be concluded that coir dust containing medium can be recommended as a suitable medium for carrot growing based on the root penetration, growth and yield of the plant.

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Introduction

Vegetables play an important part of healthy eating and provide a source of many nutrients, including potassium, fiber, folate (folic acid) and vitamins A, E and C**.** Consuming vegetables provides many health benefits such as may reduce risk for heart disease, including heart attack, obesity, type 2 diabetes and stroke, protect against certain types of cancers, may lower blood pressure and may also reduce the risk of developing kidney stones and help to decrease bone loss. According to the adaptation and growing environment it classified into upcountry vegetables and low country vegetables. The most common root vegetables are high in vitamins and minerals that they absorb from the ground. Root vegetables are full of nutrients and are an excellent source of fiber. Many are high in vitamin C, B vitamins and vitamin A. Many are high in antioxidants (www. naturalnews.com/ 048207 root vegetables health benefits).

Carrot is scientifically classified as *Daucus carota* and it is categorized as a root vegetable and it is belongs to the family of Umbelliferae. Carrot produce fleshy storage root and contain high nutritive value and also contains higher amount of carotene (l0mg/l00g), thiamin (0.04mg/100g), and riboflavin (0.05mg/100g) and it also serves as a source of carbohydrate, protein, fat, minerals, vitamin C and calories (Yawalkcr,1985). Carrot also has health benefits include reduced cholesterol, prevention from heart attacks, warding off of certain cancers, improved vision and reduced signs of premature aging. Furthermore, carrots have the ability to increase the health of skin, boost the immune system, improve digestion, increase cardiovascular health, detoxify the body and boost oral health in a variety of ways. They also provide a well-rounded influx of vitamins and minerals. It is a relatively short duration crop and gives high yield and it is economically attractive.

Carrot is one of the exotic vegetable crops and it can be cultivated in all ecological regions in Sri Lanka. Itis cultivated in Sri Lanka with an extent of 15943 Mt. The carrot is a cool weather crop and it also does well in warm climates. The optimum temperature for growth is between 15 to 20°C. The crop is tolerant to soil pH of 5.5 to 6.5 and it requires a deep and well-drained loamy soil with high amount of organic matter for good performance (Yayock *et al*., 1988).

Growing of carrot under good rooting medium is important to obtain quality root. The structure of the growing medium must be soft and porous enough, so that roots can easily penetrate widely into the material. It must also provide nutrition, anchorage and support for the plants (Utobo *et al*., 2015).

A loose, light soil or compost is always best for carrot root growth. Loosen the soil and make sure there are no stones or hard bits, if the carrot root meets any obstruction it will grow misshapen and hard (Bunt, 1988). Soil has been indicated as the easiest way through which seedlings become infected with diseases such as root knot nematode and seedling rots (Egunjobi and Ekundare, 1981). There is a need to identify the suitable rooting medium rather than soil to grow and produce quality carrot.

To increase the carrot production and its quality, modern techniques have to be introduced to farmers. Adverse climatic condition can be avoided by cultivating plants under the controlled environments like green house or net house. High temperatures influence the colour of the carrot. Quality of the carrot can be improved by using control environment and suitable rooting medium for growing. Most vegetables are established from transplants grown in trays using growing media.

Therefore, many studies have focused on vegetable seed germination and transplant establishment in various growing media (Nair *et al*., 2011). However, the effects of growing medium on vegetable production (especially post-transplant) are not well known in the world. However, only a few studies investigated the effects of the growing medium on the quality parameters of the crop. But there was no study available in Sri Lanka regarding effects of growing medium on root crops performance. By considering this gap, the study was conducted with the main objective of evaluating the effect of root penetration among different rooting media and its influence on growth and yield performance of carrot varieties. Sub objectives of this experiment are-

a. Identifying the suitable rooting medium for carrot growing.
b. Find out the root penetration level under different rooting medium

Materials and methods

An experiment was carried out in the Faculty of Agriculture, Ariviyal Nagar, Kilinochchi. It is located at Northern Province of Sri Lanka belongs to the agro-ecological region of Low Country Dry Zone (DL_3.) during the period of March to June in 2017 to evaluate the effect of different rooting media on growth and yield performance of carrot (*Daucus carota*). The Two factor factorial experiment was carried out in Complete Randomized Design (CRD) with four replicates. Four treatments (rooting media mixtures) and two carrot varieties Kimona (V1) and New Kuroda (V2) were used in this experiment was given below (Table 1). Treatments and varieties arrangements of experiment were given in the layout below (Table 2).

Table 1. Treatments of the experiment.

Treatment	Rooting media mixture ratio
Treatment 1	Top soil + Cattle manure + Coir dust 1: 1:1
Treatment 2	Top soil + Cattle manure + Leaf mould 1: 1:1
Treatment 3	Top soil + Cattle manure + Compost 1: 1:1
Treatment 4	Top soil

Table 2. Layout of the experiment

$T_1V_1R_1$	$T_1V_2R_2$	$T_1V_1R_3$	$T_1V_2R_4$
$T_1V_2R_1$	$T_1V_1R_2$	$T_1V_2R_3$	$T_1V_1R_4$
$T_2V_1R_1$	$T_2V_2R_2$	$T_2V_1R_3$	$T_2V_2R_4$
$T_2V_2R_1$	$T_2V_1R_2$	$T_2V_2R_3$	$T_2V_1R_4$
$T_3V_1R_1$	$T_3V_2R_2$	$T_3V_1R_3$	$T_3V_2R_4$
$T_3V_2R_1$	$T_3V_1R_2$	$T_3V_2R_3$	$T_3V_1R_4$
$T_4V_1R_1$	$T_4V_2R_2$	$T_4V_1R_3$	$T_4V_2R_4$
$T_4V_2R_1$	$T_4V_1R_2$	$T_4V_2R_3$	$T_4V_1R_4$

Five seeds were placed in each bag. After sowing, daily watering was done two times by using hand sprayer. Adequate amount of water was applied frequently to each bag by hand spryer to prevent damage to seedlings and avoid excess watering. After seed germination (6-7 days after sowing), bags were arranged at the spacing of 30cm × 30cm (Plate 1).

The amount of water requirement was decided based on the moisture content of the media, growing stage and weather condition.

Plate 1. Bag arrangements of one media.

Fertilizer was applied based on the recommendations made by Department of Agriculture. When weeds observed in the bags, it was removed manually. Excess plants were thinned out four weeks after planting. One plant was allowed per bag. One month after planting earthing up was done which was the time of initiation of storage accumulation in roots. Roots were covered by media to prevent the greenish colour of roots. Whenever pest and disease incidence were observed, suitable chemicals were sprayed to control that pest and disease incidence. Harvesting was done 100-120 days after planting. The carrot was harvested when the root reached the desirable size and leaves become yellowish in colour.

Measurements

EC and pH of the rooting media was measured after media preparation.

i). Weather Parameters

During the crop cultivation, temperature, relative humidity and light intensity were measured.

ii). Growth Parameters

Leaf number, leaf length and canopy diameter were measured biweekly interval.

iii). Yield Parameters

Weight of root, length of root and diameter of root were measured after harvesting.

iv). Quality Parameters

Colour of root and shape of root were taken by visual observation of carrot.

Data Analysis

The ANOVA was performed by using the GLM procedure in the SAS computer software package 9.1. Mean separation was done by using Duncan's Multiple Range Test.

Results and discussion

Results of the effect of different rooting media on growth and yield of carrot (*Daucus carota*) and economic benefits with yield variation were discussed below.

Weather Parameters

Weather parameters of temperature, relative humidity and light intensity are shown in Table 3. During this period weather parameters were not well matched with the needed requirements of the growth and development of carrot. For the carrot growth, preferable temperature range is 15 - 25°C, but during this growing period the temperature was in the range of 31.4 to 38.8°C. Top growth of the carrot will be reduced when the temperature is above the 28°C (Utobo *et al.*, 2015). But September-February period is more suitable for the carrot growing in this region.

EC and pH Contents of the Rooting Medium

The suitable pH of carrot is 5.5 – 7.0 for best growth (Utobo *et al.*, 2015).In all samples pH ranges were suitable for the carrot growing (Table 4).

Table 3. Average temperature, relative humidity and light intensity of the site during experiment period.

Parameters	Months March	April	May	June
Average Temperature (°C)	31.4	38.8	35.7	35.8
Average Relative Humidity (%)	59.7	48.1	49.4	49.1
Light intensity (klux)	43.2	48.8	40.5	37.5

Table 4. EC and pH of different rooting media.

Treatments	pH	EC (µs/cm)
T_1	5.91	634.33
T_2	6.01	413.00
T_3	6.31	1152.00
T_4	6.37	259.00

Texture of the media differed among treatments. Coir dust media had preferable texture for the carrot growing. Because coir dust media had less compaction and it is easy for the penetration of the roots, easy to drain excess water. So less chance for the water accumulation and resulted the less incidence of disease identification. Top soil had highly compacted condition, so soil had poor drainage and root penetration also difficult in this media. Due to high water accumulation caused the higher incidence of disease observation. Other two media had the characters in-between these two media. Egunjobi and Ekundare (1981) stated that most soils when used alone are very poor growing medium for carrot.

He also suggested that soil has been indicated as the easiest way through which seedlings become infected with diseases such as root knot nematode and seedling rots. Akanbi *et al.* (2002) also stated that in container or poly bags crop production, use of organic potting media substrate offers a great advantage over the conventional topsoil. Texture of the compost media also prefer for the growing of carrot. George and kelvin (2004) stated that compost is the most common potting mix ingredient among organic products and it holds water well.

Growth Parameters

Number of Leaf Number

There was significant difference among the treatments in the number of leaves per plant during their vegetative growth (Fig. 1). Leaf number did not show any significant interaction effects between varieties of carrot. But New Kuroda variety showed the highest leaf number than the Kimono variety. The highest leaf number was recorded in coir dust media (T_1) and the lowest leaf number was recorded in top soil (T_4) media. There was no significant different between leaf mould (T_3) and compost media (T_4). But highest leaf number was recorded in compost media than leaf mould media.

The difference among the treatments would be due to the different composition of rooting media. Bilderback *et al.* (2005) stated that organic components decompose during crop production and may change both the physical and chemical composition of the medium. This may in turn affect crop growth and development.

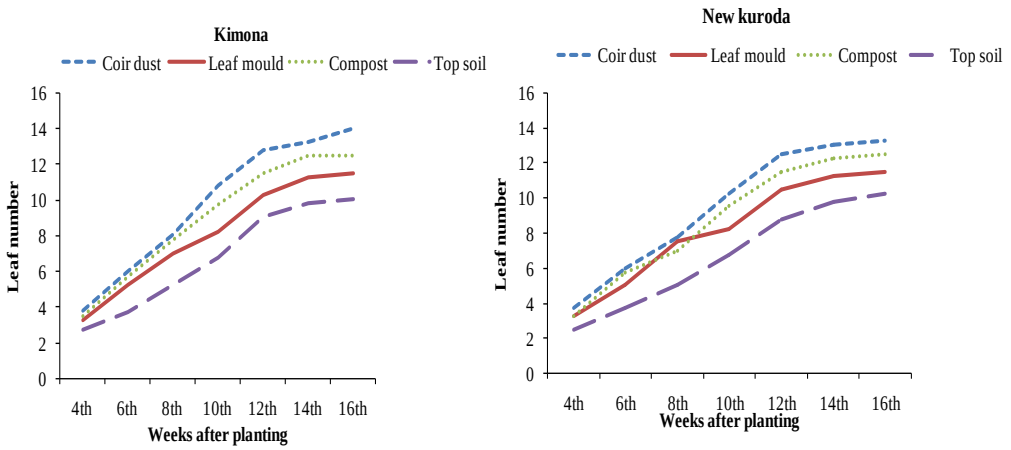

Fig. 1. Cumulative leaf number of different carrot varieties in different rooting media at two weeks interval.

Leaf Length

There was a significant different in leaf length among different growing media (Fig. 2). But there was no significant difference in leaf length between varieties of carrot. New Kuroda variety recorded the highest leaf length than Kimono variety. The highest leaf length was recorded in coir dust media and the lowest leaf length was recorded in top soil media. Leaf mould media (T_2) and compost media (T_3) were not showed any significant difference in leaf length. But the highest leaf length was recorded in compost media than the leaf mould media. The reason could be the variation in nutrient contents in different types of rooting media. Bassiony, (2006) stated that in onion, relatively high levels of nutrients are required for optimum growth and development at early stage and adequate moisture supply is most suitable during the early growth.

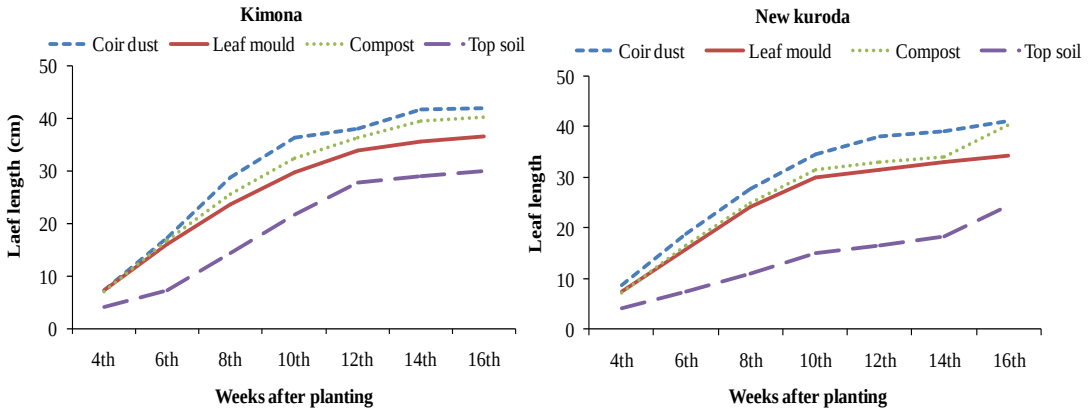

Fig. 2. Leaf length of carrot varieties in different rooting media at two weeks interval.

Plant Canopy Diameter

There was a significant different in plant canopy diameter among different rooting media (Fig. 3). Among the coir dust (T_1) and compost media (T_3) there was no significant differences. But in these two media, the highest plant canopy diameter was obtained from coir dust media than compost media.

The lowest plant canopy diameter was obtained from top soil. But the plant canopy diameter did not show any significant interaction effects with varieties of carrot. But highest plant canopy diameter was recorded in New Kuroda variety than Kimona variety. Amount of nutrient content in rooting media might be the reason for the better performance of canopy diameter of carrot. This result was agreed with Moldes *et al.* (2007), they claimed that the application of mature compost at reasonable rates improved plant growth and soil physical properties, and increased the available soil nutrient levels.

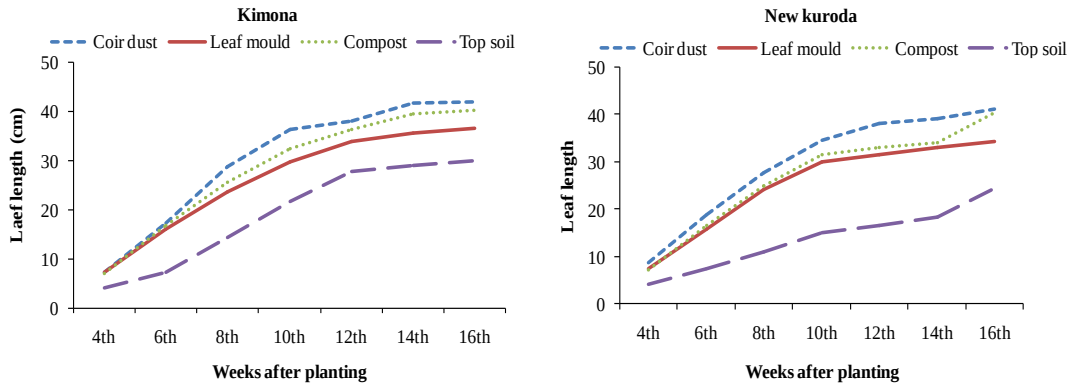

Fig. 3. Canopy diameter of carrot varieties in different rooting media at two weeks interval.

Among the rooting media, coir dust showed the best performance in growth parameters of leaf number, leaf length and plant canopy diameter. The difference among the treatments would be due to the different compositions of rooting media. Utobo *et al.* (2013) stated that the potting media mixture significantly affected all the vegetative growth parameters in plants.

Yield Parameters

Root Length (cm)

There was a significant difference in root length among different rooting media (Fig.4). Maximum root length was observed in the coir dust media (T_1). But there was no significant differences in root length among leaf mould media (T_2) and compost media (T_3). The lowest root length was observed in the top soil (T_4). There was no significant difference between varieties of carrot in root length.

But highest root length was recorded in Kimona than New Kuroda variety. The difference among the treatments would be due to the texture of the media which facilitate the good aeration and easy penetration in the media.

Bilderback *et al.,* (2005) stated that growing media have three main functions: 1) provide aeration and water, 2) allow for maximum root growth and 3) physically support the plant. Growing media should have large particles with adequate pore spaces between the particles. Appropriate particle size selection or combination is critical for a light and fluffy (well-aerated) medium that promotes fast seed germination, strong root growth and adequate water drainage.

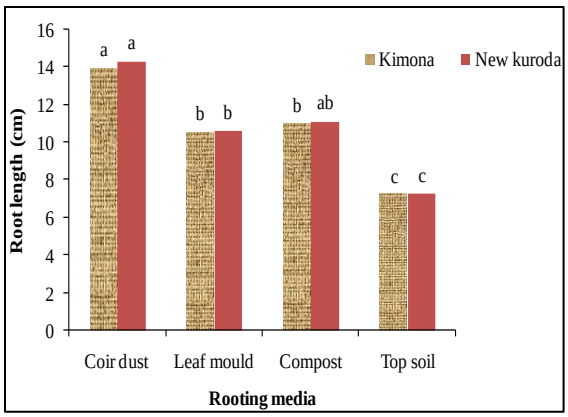

Fig. 4. Average root length of carrot plant in different rooting medium.

Root Circumference (cm)

There was a significant difference in root circumference among different rooting media (Fig. 5). The highest root circumference was observed in coir dust containing media (T_1) and the lowest root circumference was observed in top soil media (T_4). There was no significant difference in leaf mould media (T_2) and compost media (T_3).

But the highest value was observed in compost media than leaf mould media. There was no significant difference in root circumference among carrot varieties. But the highest root circumference was recorded in New Kuroda variety than Kimona variety.

The difference among the treatments would be due to the texture of the different rooting media. Mohotti (1999) stated that coir dust is characterized with high C: N ratio and its physiochemical properties are very favorable for rooting in container for the tuber crops.

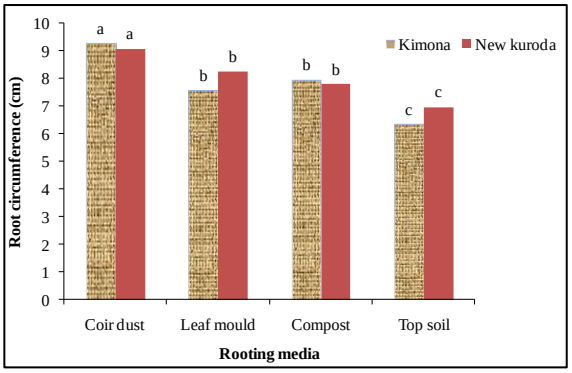

Fig. 5. Average root different circumference of carrot in rooting media.

Yield

There was a significant difference in yield among different rooting media (Fig.6). The highest yield was obtained from coir dust media and the lowest yield was obtained from top soil media. There was no significant variation between leaf mould media and compost media. But among these two media the highest yield was obtained from compost media than the leaf mould media. There was no significant difference in yield among carrot varieties. But New Kuroda was recorded the highest yield than Kimono variety.

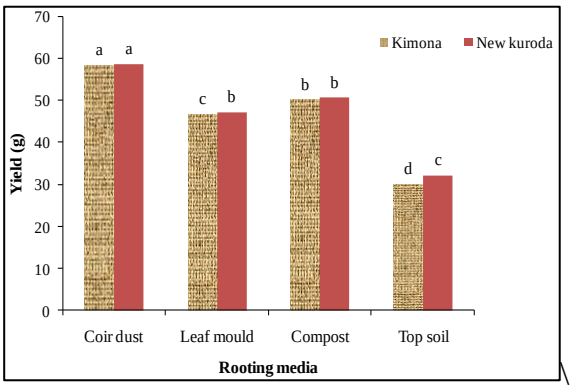

Fig. 6. Average yield of carrot in different rooting media.

Quality Parameters

There were no significant differences in root weight and root size (length and circumference) between Kimona and New Kuroda varieties (Table 5). The highest root weight was observed in New Kuroda variety (58.56cm) compared to Kimona (58.35cm) variety. Similarly highest root length (14.33cm) was observed in New Kuroda variety and the lowest root length (13.95cm) was observed in Kimona variety. But the highest root circumference (9.28cm) was obtained from Kimona variety and the lowest value (9.08cm) was obtained from New Kuroda variety.

Table 5. Summary of Yield Parameters.

Media	Root length (cm) Root circumference (cm) Root weight (g)
	Kimona New Kuroda Kimona New Kuroda Kimona New Kuroda
Coir dust	13.9 14.3 9.2 9.0 58.3 58.5
Leaf mould	10.5 10.6 7.5 8.2 46.6 47.1
Compost	11 11.1 7.9 7.8 50.1 50.5
Top soil	7.2 7.2 6.3 6.9 30.1 32.2

Size of carrot is an important parameter for table purpose. Average size carrot is suitable for fresh market. Gruda (2009) strongly suggested that changes in the quality parameter of many vegetables in response to the growing medium used. Utobo *et al.* (2015) reported that rooting media also significantly affected the entire yield and yield parameters of carrot. Griffin and Porter, (2004); Elisabetta and Nicola, (2009) stated that compost application to the soil has several beneficial effects on crop yield and soil fertility by improving and increasing soil organic matter, water holding capacity, nutrient contents, soil aggregation and microbial activity.

When consider about colour of the roots, in all media roots were light orange colour. This could be due to high temperature of the site. Rubatzky *et al.*, (1999) stated that high temperature caused for the light colour of roots. Taste of carrot also bitter in both varieties in all media. Extremely high temperatures cause a bitter taste, reducing sweetness and increasing fibrous texture of the storage root (www.hunker.com/13427432/what-causes-my-carrots-to-be-bitter). Well shape and big size roots were obtained from coir dust media. In leaf mould and compost media also has given well shape and moderate size roots. But in top soil media roots were not in good size as well as shape.

Conclusions

Growth and yield performance of carrot grown in bags were influenced by the composition of rooting media. When considering both yield and growth parameters, there was no difference in carrot varieties Kimona and New Kuroda and they equally well.

Leaf number, leaf length, plant canopy diameter, root length, root circumference and root weight were significantly affected by different growing media. There was a non-significant different of leaf number, leaf length, plant canopy diameter, root length, root circumference and root weight of the carrot plant in both carrot varieties. In both varieties of carrot, coir dust containing media showed the best performance and gave the highest yield and top soil (control) media showed the highest disease incident compare the other three media and gave the lowest yield. It can be concluded that coir dust media could be recommended as a suitable media for growing carrot varieties to obtain quality and high yield in carrot.

Suggestion

Other locally available materials like wood shavings, partially burnt paddy husk can also be used as rooting media and experiment can be repeated for both *Maha* and *Yala* seasons to get consistency.

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