



University of Debrecen | 2018

ACTA AGRARIA
DEBRECENIENSIS **74.**

Established: 1966.

ACTA AGRARIA DEBRECENIENSIS

Journal of Agricultural Sciences

This peer reviewed journal of Faculty of Agricultural and Food Sciences and Environmental Management of the Debrecen University, Debrecen, Hungary.

The Journal of Agricultural Sciences publishes papers in English.

Professional support is provided by Hungarian Academy of Sciences, Section of Agricultural Sciences, Kerpely Kálmán Doctoral School and Animal Husbandry Doctoral School of Debrecen University.

The Journal is published in yearly volumes of two issues annually.

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CONTENTS

Loránd Alexa – Andrea Kántor – Béla Kovács – Nikolett Czipa Determining the antioxidant compounds of beer	5
Oqba Basal – András Szabó Physiological traits and yield of three soybean (<i>Glycine max</i> (L.) Merr.) genotypes as affected by water deficiency	11
Janka Bedő – Eren Baris – Zsolt Szani – Dezső Surányi – Erzsébet Kiss – Anikó Veres SSR based characterization of peach (<i>Prunus persica</i> L.) and apricot (<i>Prunus armeniaca</i> L.) varieties cultivated in Hungary	17
Dominika Bodnár – Kitti Csüllög – Gábor Tarcali Review of the biology of plant psyllid (<i>Cacopsylla pruni</i> , Scopoli 1763), and its role in the spreading of European stone fruit yellows, ESFY-phytoplasma with Hungarian data	25
Karina Bianka Bodnár – Seyed Mohammad Nasir Mousavi – János Nagy Evaluation of dry matter accumulation of maize (<i>Zea mays</i> L.) hybrids	35
Zsuzsa Erdős Effect of agrotechnical factors on the yield of the Grolim asparagus (<i>Asparagus officinalis</i> L.) hybrid on acidic sandy soil	43
Ágnes Fekete – Péter Pepó The role of green manure crops in Hungarian plant production	49
Dóra Frommer – Szilvia Veres – László Radócz Susceptibility of stem infected sweet corn hybrids to common smut disease	55
Tibor Horváth – Anikó Nyéki – Miklós Neményi The energy balance of maize production – alternative approaches	59
Evelin Kármén Juhász – Andrea Balláné Kovács The effect of sulphur and nitrogen supply on the growth and nutrient content of spring wheat (<i>Triticum aestivum</i> L.)	65
Andrea Kántor – Loránd Alexa – Béla Kovács – Nikolett Czipa Determination of element contents of commercial and homemade jams	71
Gabriella Kovács – Dominika Bodnár – Gábor Tarcali – László Radócz Biological control of sweet chestnut on Pécsbánya, Hungary	77
Péter Kovács The effect of and interaction between the biological bases and the agrotechnical factors on maize yield	83
Péter Kovács – Mihály Sárvári Correlation between the weather in 2017 and the productivity of maize	89
Éva Judit Lelesz The purple coneflower's (<i>Echinacea purpurea</i> L.) nutrient requirements investigation in a small plot trial	95
Judit Éva Lelesz – József Csajbók Analysis of different fertilization settings' effect in the case of the summer savory's (<i>Satureja hortensis</i> L.) yield and active agents	101
Péter Makleit – Dóra Frommer – Szilvia Veres Establishing biotic stress tolerance of maize (<i>Zea mays</i> L.) by measuring hydroxamic acid contents	107
Judit Molnár – Erika Lakatos – Balázs Ásványi Influencing the growth kinetics of yeast strains with vitamin supplementation	113
Anna Novák – Loránd Alexa – Béla Kovács – Nikolett Czipa Comparative study of special honey products and herbhoneys	117
Szilvia Orosz – László Bujdos – Lajos Varga – Tibor Fekete Investigations of <i>Thrips tabaci</i> and <i>Aeolothrips intermedius</i> population dynamics in tobacco plantations	121

Effect of agrotechnical factors on the yield of the Grolim asparagus (*Asparagus officinalis* L.) hybrid on acidic sandy soil

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SUMMARY

Research of blanched asparagus has begun at the University of Debrecen Institutes for Agricultural Research and Educational Farm Research Institutes of Nyíregyháza in 2011. Establishment of the plantation took place in May 2011. The Grolim hybrid was used in the trial, 16 medium plot trial area has been formed under field conditions, with four repetitions and 36 m² plot size. In the course of our studies, the effect of different nutriment supply methods (untreated, manure, sheep manure compost, fertilizer) has been analysed on the spear yield of the Grolim asparagus hybrid between 2013 and 2017.

In our studies, the beginning of vegetative growth has been recorded upon the constant presence of 10 °C of average soil temperature in the case of the Grolim asparagus hybrid. The beginning and length of spear harvesting are both influenced by the time and dynamics of initial development in spring. During the analysed period, the dates of spear harvesting were various, the earliest being on 23rd March, 2014 and the latest on 23rd April, 2015; the rest of the three years have been varied within this one month interval. The total of heat units required for the vegetative development of spears has been determined; it provides important information for cultivation practice.

Spear yields turned out to be hectic during the analysed period. In 2013 and 2014, yields have surpassed the amount of 50 kg/harvest period/plot in the case of every treatment version. However, in 2015 a significantly lower specific yield has been recorded due to the unfavourable weather conditions in spring; a yield decline of nearly 50% was recorded in the case of the control treatment compared to the previous years. Yield was also lower in the rest of the fertilization treatments compared to 2014; however, in these cases, the degree of yield decrease was around 5–10%, which suggests the yield stabilising effect of fertilization. In 2016, a slight yield increase was measured in comparison with the base year. In 2017, there was a decline of yield in the control treatment; however, the different fertilization treatments resulted in yield increase as compared to previous years.

On the basis of our studies, it is clear that the best yield results have been provided by the artificial fertilization treatment in all of the five analysed years. It was followed by the sheep manure compost and manure treatments in terms of their effect on spear yield. During the three harvesting periods, the lowest yield on acidic sandy soil was recorded in the case of the control treatment. The most remarkable effect of nutriment treatments has been realised in terms of the decreased deviation of yield results, which perfectly represents the yield stabilising effect of nutriment supply in the case of perennial crops – asparagus – as well, even on a poor nutriment supply characteristic sandy soil.

Keywords: cropyear, asparagus, acidic sandy soil, fertilization methods, yield

INTRODUCTION

The origin of asparagus (*Asparagus officinalis* L.) can be traced back to 2500 years, which is verified by a number of preserved written records. Asparagus species, which are nowadays utilised in public production, were probably known and consumed by the ancient Egyptians. It was a popular meal in the Roman Empire a few hundred years ago B.C. For ancient Greeks, asparagus was considered not only as an essential nutritional item, but also as a medicine and as a cleansing material for the human body. Wild varieties of asparagus plant are indigenous in both Asia and Europe. In Europe, the following wild and domesticated varieties have become the most widespread: *Asparagus acutifolius*, *A. tenuifolius*, *A. maritimus* or *A. officinalis* which is cultivated on the largest area (Cerne et Kacjan Marsic 2002).

Asparagus is a perennial crop that is able to grow for 15 to 20 years following planting, but in intensive cultivation, this period is limited to 10–12 years. The strong roots of the plant make it possible for the asparagus spears to be economically harvested without the complete depletion of the root system, but at the same time, it is important for the production area to

always have sufficient amount of nutrients (Pressman et al. 1993, Drost 1997, Fehérmé 2005).

One of the earliest vegetable crops is asparagus, harvesting season lasts from April to June, harvesting can begin as of the third year after plantation. In relation with its earliness, special requirements of asparagus involve soil, precipitation and light and temperature conditions. During the harvesting period, its heat optimum is +19 °C, but ±14 °C does not cause irreversible damage to the spears (Fehérmé 2005). Dean (1999) determined the heat threshold of growth of asparagus at 10 °C. Asparagus prefers temperate climatic conditions, its optimum root and shoot growth s realised between 18 and 29 °C (Brenna et al. 2011). In contrast, according to Dean (1999), heat threshold of growth of shoots is between 24.5 and 33 °C. In his studies, maximum spear growth was observed at 30 °C (0.51 cm h⁻¹ growth). There was a close correlation between daily temperature and spear yield but no statistically confirmed correlation was established. Wilson et al. (1999) found that the heat threshold of asparagus growth was 7.1 °C based on the analysed data, but different heat threshold values were determined at each test sites. Based on studies carried out in the United States, a developmental heat threshold of 6.7 °C, while in Japan 4.8 °C was found with significant

variety effect. Bouwkamp and McCully (1975) determined the heat threshold at 4.4 °C, while Blumenfield et al. (1961) set this value at 7.2 °C.

Asparagus tolerates drought, but under intensive cultivation circumstances, proper and balanced water supply is important for economic growth, which, in many cases can only be achieved by irrigation. The most suitable soil for cultivation is sandy soil with loose texture, which is free of perennial weeds, stones and impermeable soil layers, so it is easier to harvest higher quality and more straight spears. In addition to water supply and soil properties, nutrient supply is also an important cultivation technology factor. The most suitable soil for cultivation is sandy loam soil with an ideal pH of between 6.5 and 7.5, and the soil is free of stones, impermeable soil layers and perennial weeds (Ku 2006). Asparagus belongs to nutrient sensitive crops. To produce 1 t of blanched asparagus, 30 kg N, 12 kg P₂O₅, 36 kg K₂O, 3.6 kg Mg and 2.1 kg Ca nutrient is required. Nitrogen absorption is considered the most dynamic, which might last from mid-April to the end of June. In contrast, phosphorus and potassium uptake is much slower; it could be constant even until the end of August (Laczkó 2005, Fehérné 2005, 2009).

MATERIAL AND METHODS

The examinations have been carried out at the 2011 established asparagus plantation of the University of Debrecen Institutes for Agricultural Research and Educational Farm Research Institutes of Nyíregyháza. The plantation was carried out with a row spacing of 180 cm, and plant spacing of 25 cm, with a plant density of 22 300 plants hectare⁻¹. The soil of the trial area is typically a good condition humous sandy soil (K_A 30) with low acidity (pH 6.71) and medium humus content [1.23% (m/m)] (Table 1).

Table 1
The most important soil parameters on the experimental site of the asparagus (Nyíregyháza, 2015)

Parameter	Result	Unit
pH _{KCl}	6.71	
Compaction with Arany method (K _A)	30	
Water-soluble salts	0.02	% (m/m)
All carbonate content in CaCO ₃ expressed	0.417	% (m/m)
Humus content	1.23	% (m/m)
AL-soluble P ₂ O ₅	175	mg kg ⁻¹
Al-soluble K ₂ O	169	mg kg ⁻¹
KCl-soluble NO ₃ ⁻ +NO ₂ ⁻ -N	15.7	mg kg ⁻¹
AL-soluble Na	40.6	mg kg ⁻¹
KCl-soluble Mg	50.7	mg kg ⁻¹
KCl-soluble (SO ₄) ₂ ²⁻ -S	1.62	mg kg ⁻¹
KCl-EDTA soluble Mn	42.5	mg kg ⁻¹
KCl-EDTA soluble Zn	2.95	mg kg ⁻¹
KCl-EDTA soluble Cu	1.83	mg kg ⁻¹

In the course of the trial, the asparagus hybrid Grolim was examined, which is a 100% male, Dutch bred hybrid. This hybrid has one of the earliest harvesting periods. Its spears are thick the heads are tight. In field conditions, a trial area of 16 medium plots has been established, where each plot has a size of 36 m². There were four nutriment supply variants: in addition to the untreated control 40 t ha⁻¹ manure, 40 t ha⁻¹ sheep compost fertilizer and 40 t ha⁻¹ stable manure equivalent fertilizer have been applied. In terms of weather, five years of harvesting have been compared to the evaluation of precipitation data.

The meteorological data were measured with the AgroSense meteorological station and its substations. In the trial area from 1st March to 30th June, the following amounts of precipitation were recorded: 231.5 mm in 2013, 119.9 mm in 2014, 109.8 mm in 2015, 194.2 mm and 249.5 mm until October 2016. In 2015, there was a significant lack of precipitation (only 109.8 mm precipitation fell from March to June) in the area, which already had a negative effect on the development of the plants in early spring. In 2017, there was 249.5 mm of precipitation from March to June, which was the highest amount of precipitation during the growing period within the analysed five years, but its distribution was very hectic. In terms of the analysed months, it exceeded 60 mm in April and 110 mm in June (Figure 1).

In addition to the development of precipitation data, air and soil temperatures are the most determinant in the spring emergence of asparagus spears. 2013, 2015, 2016 and 2017 are can be considered average in terms of air temperature, however in 2014 it was observed that March was warmer than the average, which could result in earlier harvesting (Figure 2).

In our examinations, the beginning of vegetative development was experienced upon the steady existence of 10 °C of average soil temperature in the case of the Grolim asparagus hybrid. The beginning of spear harvesting and the length of the harvesting period are both influenced by the beginning and dynamics of spring development. Soil heat units required for the vegetative development of spears have been examined by means of the method of Bouwkamp and McCully (1975) and Blumenfield et al. (1961) in all five years of harvesting, which provides important information for harvesting practice. For the statistical analysis of yield results, Microsoft Office Excel and SPSS software have been utilised. For statistical reliability analyses, a significance level of 5% has been determined.

Figure 1: Amount of precipitation on the trial areas (Nyíregyháza, 2013–2017)

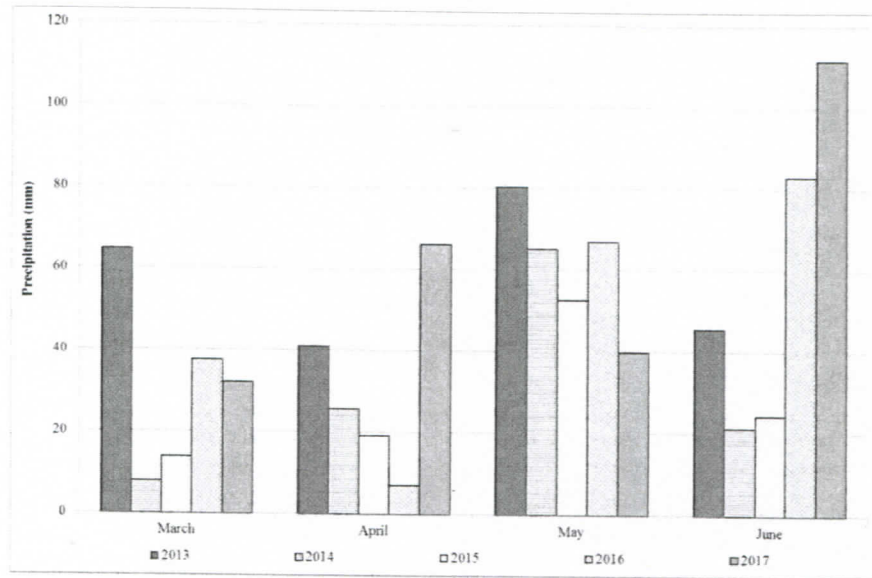
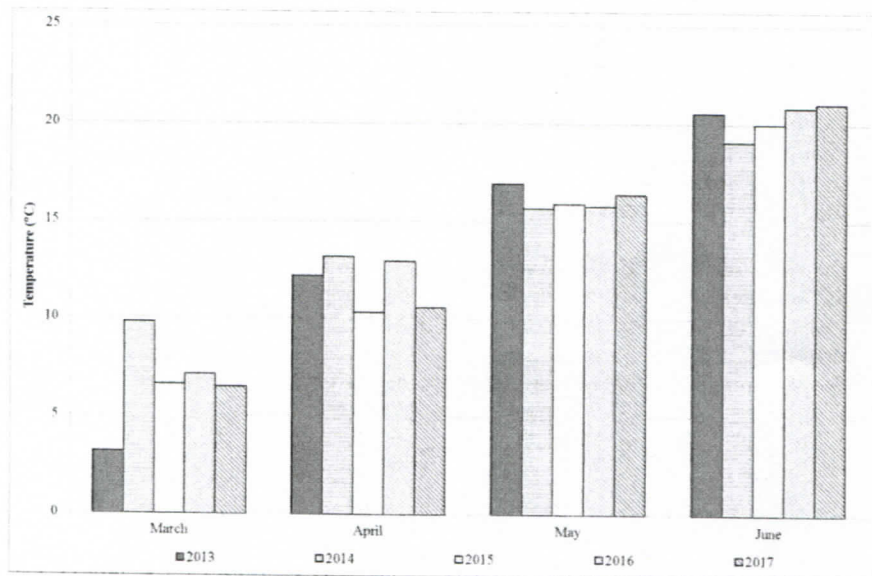


Figure 2: Changes of temperature on the trial areas (Nyíregyháza, 2013–2017)



RESULTS

In the course of my research the effect of different nutriment supply methods have been analysed on the spear yield of Grolim asparagus hybrid during the

period of 2013–2017. As a basis of the study, the first 20 days of harvesting have been analysed every year. The determining parameters of the harvesting periods are shown in detail in *Table 2*.

The main data of Grolim asparagus harvesting period (Nyíregyháza, 2013–2017)

Table 2

Main data	The Grolim asparagus harvesting period (day/month/year)				
Soil temperature has reached 10 °C	19.04.2013	02.03.2014	12.04.2015	01.04.2016	30.03.2017
Emergence of the first spear	25.04.2013	25.03.2014	15.04.2015	08.04.2016	05.04.2017
Beginning of harvesting	28.04.2013	28.03.2014	18.04.2015	11.04.2016	09.04.2017
End of harvesting	17.05.2013	16.04.2014	07.05.2015	30.04.2016	28.04.2017
Period of harvesting	20	20	20	20	20

For determining the starting period of harvesting, effective heat unit calculation was carried out in terms of air and soil temperature. Effective heat unit based on air temperature resulted on significantly different heat unit data (Table 3). Based on the method of Bouwkamp and Mccully (1975) the effective air temperature sums changed between 174.05 and 204.55 °C, while on the basis of the growth heat threshold determined by Blumenfield et al. (1961) the effective heat unit changed between 97.69 and 143.90 °C.

temperature values, clear and similar results were obtained in different production years, indicating a lower deviation of the effective heat unit determination based on soil temperature (Table 4). According to Bouwkamp and Mccully (1975), the effective air temperature sums based on the soil temperature varied between 73.2 and 108.8 °C, while based on the heat threshold of Blumenfield et al. (1961), the effective heat unit based on soil temperature ranged from 35.30 to 48.90 °C.

Table 3
Development of effective heat unit calculated based on air temperature (°C) in the case of the Grolim asparagus hybrid (Nyíregyháza, 2013–2017)

Year	According to Bouwkamp and Mccully (1975)	Based on Blumenfield et al. (1961)
2013	204.55	105.90
2014	193.55	143.90
2015	174.05	102.80
2016	199.40	107.38
2017	200.25	97.69

Table 4
Development of effective soil temperature based on soil temperature (°C) in the case of the Grolim asparagus hybrid (Nyíregyháza, 2013–2017)

Year	According to Bouwkamp and Mccully (1975)	Based on Blumenfield et al. (1961)
2013	108.10	35.30
2014	73.20	39.50
2015	102.34	43.28
2016	88.00	48.90
2017	102.95	46.34

For the statistical evaluation of the effects of treatments, Tukey-test was utilised, where the chosen significance level was 5% (Table 5). The analysis showed that significant difference is recorded compared to the control treatment in the case of compost treatment, stable manure treatment and artificial fertilizer treatment in terms of the effect on spear yield.

During the five years of harvesting, in the control treatment, compared to 2013 and 2014, a nearly 50% decrease in terms of yield was recorded. In 2017, the highest crop yield was achieved by fertilizer treatment (14.01 kg/plot/harvesting period), followed by sheep manure compost (13.03 kg/plot/harvesting period), stable manure treatment (10.92 kg/plot/harvesting period) and finally control treatment (2.63 kg/plot/harvesting period) (Figure 3).

In the case of the determination of effective heat unit required until the emergence of harvestable spears determined with the help of the average soil

Figure 3: Effect of production year and fertilizer methods on the yield of Grolim asparagus hybrid (*Asparagus officinalis* L.) (Nyíregyháza, 2013–2017)

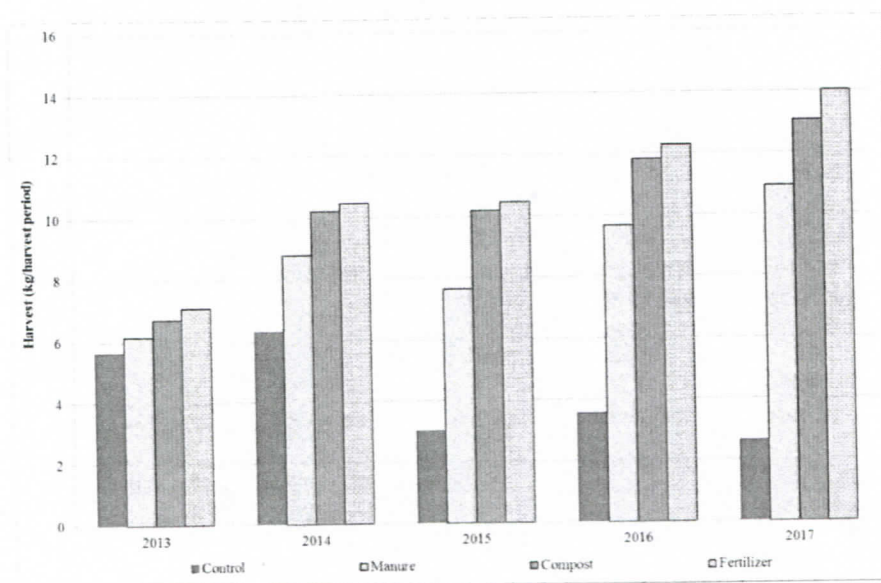


Table 5

The statistical analysis of the effect of the different fertilization methods on the yield of Grolim asparagus hybrid (Nyíregyháza, 2013–2017)

		Grolim asparagus hybrid			
		Control	Manure	Compost	Fertilizer
Grolim asparagus hybrid	Control	0	-4.39000 (*)	-6.16000 (*)	-6.61800(*)
	Manure	4.390000(*)	0	-1.77000	-2.22800
	Compost	6.16000 (*)	1.77000	0	--.45800
	Fertilizer	6.61800 (*)	2.22800	0.45800	0

Note: * significantly different groups, significant at level 0.05.

DISCUSSION OF THE RESULTS, CONCLUSIONS

Based on my studies, it can be concluded that the highest yield was achieved in the artificial fertilizer treatment in all five harvesting periods. Smaller yield increase resulted by the sheep manure compost and stable manure treatments. In the five examined harvesting periods, the control treatment had the lowest spear yield. The effect of various nutrient treatments manifested itself in the decrease yields deviations, which clearly demonstrates the yield stabilising effect of nutrient supply. This is also important for asparagus because moderate fertilization reactions occur in the case of perennial plants, but the sensitivity of the plant to nutrient supply in the case of asparagus has become clear based on the test results.

It can also be stated that soil temperature is one of the most important factors in the emergence time of spears. Our observations have shown that the emergence of spears is expectable once soil temperature rises steadily above 10 °C. In the course of calculating the effective heat unit, it was established that in the case of the Grolim hybrid and assuming a 4.4 °C heat threshold, the emergence of spears was experienced upon reaching an effective heat unit of 105.90 °C in 2013, 143.90 °C in 2014, 102.80 °C in 2015, 107.38 °C in 2016 and 97.68 °C in 2017. Assuming a growth threshold of 7.2, the emergence of

spears was experienced upon reaching an effective heat unit of in 35.30 °C in 2013, 39.50 °C in 2014, 43.28 °C in 2015, 48.90 °C in 2016 and 46.34 °C in 2017. Our studies have confirmed the production year dependence of asparagus spear yield. In 2016 and 2017, early warming and a favourable amount of precipitation during the harvesting period resulted in a significant increase in terms of spear yield in all three nutrient treatments. During the five years of harvesting. In 2017, the highest crop yield was achieved by fertilizer treatment (14.01 kg/plot/harvesting period), followed by sheep manure compost (13.03 kg/plot/harvesting period), stable manure treatment (10.92 kg/plot/harvesting period) and finally control treatment (2.63 kg/plot/harvesting period). The analysis showed that significant difference is recorded compared to the control treatment in the case of compost treatment, stable manure treatment and artificial fertilizer treatment in terms of the effect on spear yield.

ACKNOWLEDGEMENT

Our analysis have been carried out in the scope of the „Supported by the ÚNKP-17-3 New National Excellence Program of the Ministry of Human Capacities” and „Supported by the NTP-EFÖ-P-15 Scholarships providing unique development of the Ministry of Human Capacities”.

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