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ORGANIC AGRICULTURE IN TERMS OF SUSTAINABLE DEVELOPMENT OF SERBIA

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Abstract

Achieving sustainability gives an answer on question what is a sustainable agroecosystem? Sustainability has been the background context of nearly every topic addressed so far. This paper proposes a framework for setting the parameters for sustainability, outlines indicators that can tell us if we are moving in the necessary directions, and sets criteria for the research needed to fashion a more sustainable path in agriculture. The concept of sustainable development and the complex analysis of the state of the environment require from agriculture to produce enough food in a manner that does not endanger the environment. Due to the significant percentage of the population living in rural areas, because of the high percentage of gross domestic product, as well as the growing adverse impact that agriculture has on the environment, our country needs a strategy of sustainable development in agriculture. One of the goals of the sustainable agriculture is to create farming systems that mitigate or eliminate environmental harms associated with industrial agriculture. That aim can be realized only in flexible cultural practices in real agroecological conditions (different regional characteristics, soil types, adapted cultivars for low-input or organic production). The transformation from conventional to sustainable organic field crop technology production requires changes and adaptation of many cultural practices. Organic farming is one of the most interesting current trends in agriculture entirely based on ecological principles and the absence of agricultural chemicals use (pesticides, fertilizers, antibiotics, hormones, GMOs, etc. The Republic of Serbia has significant natural resources and favorable conditions for agricultural production, which can meet the basic requirements for the establishment of organic farming, due to less contamination of soil and water, and to less use of pesticides and other chemicals.

Key words: *organic agriculture, sustainable development, environmental protection*

Introduction

The development of agriculture enabled the development of the human population, but directly and indirectly affecting the environment. On the other hand, agriculture creates the basic resources for human survival – food on only 10% of arable land on Earth. The concept of sustainable development and the complex analysis of the state of the environment require from agriculture to produce enough food in a manner that does not endanger the environment. Due to the significant percentage of the population living in rural areas, because of the high percentage of gross domestic product, as well as the growing adverse impact that agriculture has on the environment, our country needs a strategy of sustainable development in agriculture. Sustainable agriculture is an exact example of anticipated concept of future development of agriculture in general. Term "sustainable agriculture" could be defined as a direction of agricultural development. It needs to secure satisfaction stability of food production and plant production used in other technical purposes, with respect to basic natural resources, energy, ecology, economical efficiency and profitability in the same time. The

most important thing regarding a global sustainable system is to avoid conflict between economy and ecology as two opposite goals. Global considerations about this problem lead to first concrete results. These results guide unloading of world's conventional (industrial) production. Industrial agriculture depends on expensive inputs from off the farm (e.g., pesticides and fertilizer), many of which generate wastes that harm the environment; it uses large quantities of nonrenewable fossil fuels and it tends toward concentration of production, driving out small producers and undermining rural communities. Resource-intensive agricultural practices are considered unsustainable for two reasons: much of the consumption is of nonrenewable resources, in particular, fossil fuels and consumption of some renewable resources is occurring faster than the rate of regeneration. The bad characteristics of that kind of development may be slowly directed to the alternate directions of development, based on biological foundations. The proliferation of industrial animal agriculture creates environmental and public health concerns, including pollution from the high concentration of animal wastes and the extensive use of antibiotics, which may compromise their effectiveness in medical use. Transition from industrial agriculture (intensive cultural practices, feedlot farming etc.) with intensive technologies of crop production (conventional tillage, usage of huge amounts of fertilizers and pesticides, GMO, hormones and antibiotics), to sustainable systems takes over low-input technologies (Kovacevic, 2004a; Kovacevic et al., 2004b) as result of domination of ecological paradigm.

Currently, different directions in which agriculture is conceived are existing, weather it is represented as industrial, so called very intense, or conventional one followed also by many environmental trends based on strict principles of environmental inputs. Conventional agriculture has a duty to ensure maximum production in terms of quantity and quality at the lowest cost. For these purposes, a variety of agro/cultural practices are available, sometimes with many negative long-term effects in agro/ecosystems, in addition to the expected positive effects (Kovacevic et al., 2010).

One of the national priorities for achieving sustainable development in the Republic of Serbia refers to the protection and enhancement of the environment and rational use of natural resources (Official gazette, 2008). One of the priorities of the National Strategy for Sustainable Development of the Republic of Serbia (priority 5) is the protection and enhancement of the environment and rational use of natural resources. Preservation and improvement of the system of environmental protection, pollution reduction and environmental pressures, the use of natural resources in a manner to ensure their availability for future generations through: the establishment of the protection and sustainable use of natural resources (air, water, soil, mineral resources, forests, fish, wildlife and plant species); strengthening interaction and achievement of significant effects between environmental protection and economic growth, integrating environmental concerns into development policies of other sectors; investing in reducing environmental pollution and the development of cleaner technologies; reducing the high energy intensity of the economy of the Republic of Serbia and the efficient use of fossil fuels; promoting the use of renewable energy sources; planning of sustainable production and consumption and reducing waste per unit of product; protection and conservation of biodiversity.

Organic farming has a positive effect on the stability of a specific geographic area. This opens possibilities for the development of the concept of multifunctional agriculture, reducing migration of rural population to the cities, contributing to the development of local communities, strengthening and expanding the market, particularly in the areas of protected nature in which sustainable development from agriculture system is imperative, because of the wider public interest in the preservation of natural resources the production of which is relied upon (Oljača, 2003; 2005).

However, when it comes to organic field production it is necessary to choose field types of plants without normal use (alternative), suitable for this type of production (Pearson et al., 2004; Bavec and Bavec, 2007). The highest yielding cultivars with best quality in conventional systems are not the highest yielding cultivars with the best quality in organic systems, would suggest the need for breeding and selection under organic conditions (Murphy et al., 2007). Some of these grains may be of local significance or of limited markets, and some are interesting on the so oriented farms (Kovacevic et al., 2011).

Organic agriculture in the world

Organic food production is the only way of agricultural production, which, at the same time, provides an opportunity to integrate environmental conservation and improvement of quality of life with economic and social aspects (Oljača, 2004). Although, organic farming as a concept, exist more than 80 years, until the mid -1980s became the spotlight of consumers, producers, environmentalists and policy-makers across Europe. Customer requirements for products from organic agriculture were beginning to grow rapidly, which leads to active participation of traders in this sector and an increase in the price of these products. Support for organic production is tight these days in Europe, because they recognize its benefits and contribute to the objectives of rural development and environmental improvement. The last ten years the production and processing of organic products is becoming increasingly popular and economically significant. Organic farming is now practiced in more than 160 countries worldwide. According to the latest data, under cultivation is 37 million hectares to 1,8 million registered farms. This accounts for 0,9% of agricultural land in the world (Willer and Kilcher, 2012). Organic products occupy only about 1-2% of the world food market, and the potential is huge. The demand for these products in recent years has been growing because of growing awareness of environmentally concerned consumers. The prices of organic products exceed the price of the products of conventional agriculture by 10-40% on average. Economically developed countries of EU, USA, Canada and Australia already have a developed awareness of the benefits of the organic products. In Western countries, the average index of growing demand for organic food is around 8-10 % per annum which means that soon the turnover share of certified food will be around 5 %, which means that turnover is about $ 60 billion on a global level (FIBL-AMI, 2012). It is necessary to emphasize that climate, historical heritage and public sector support organic production make some countries the leaders in a given type of organic production (Pereira, 2003). Organic agriculture is more energy efficient with smaller carbon footprint compared to conventional one (less harmful gases). It uses alternative energy sources very frequently. It produces 28% more carbon, and it is estimated that during one year it can fix, in this production type, 1000 kg of C per ha of soil.

Organic agriculture obtains its full value by multifunctionality - production of agricultural and non-agricultural products and services by preserving agricultural landscape. It creates conditions for better quality and richer touristic offer and contributes to integral rural development (Lazic, 2010).

Organic agriculture in Serbia

Organic farming is one of the most interesting current trends in agriculture entirely based on ecological principles and the absence of agricultural chemicals use (pesticides, fertilizers, antibiotics, hormones, GMOs, etc. The Republic of Serbia has significant natural resources and favorable conditions for agricultural production, which can meet the basic requirements for the establishment of organic farming, due to less contamination of soil and water, and to less use of pesticides and other chemicals. Organic production is characterized by a certain transition period of conversion, greater biodiversity, changed agricultural practices and the necessary certification. (Kovacevic and Lazic, 2012).

There are 11099 ha of arable land under the certification in Serbia in 2012, according to the study of GIZ (Martz et al., 2013). The fruits dominate with nearly 5145 ha, mostly apples and plums. According to these data, about 829000 ha are certified for collection from the wild (wild fruits, herbs, and mushrooms). The most important resources are the areas around the protected natural resources especially those with high natural values. At least 4000 farms practice organic farming, and 60 % of them have less than 6 ha and 25% of them have 10-20 ha of land. Most of these farms are in Vojvodina then, in west and south of Serbia. The total value of organic production is estimated at around € 25 million, and most of these products are exported, due to poorly developed domestic market. It was also stressed that around 25 companies successfully engaged in the processing and production of finished organic products. Organic food market in Serbia is underdeveloped because of the lack of demand, consumers have not sufficiently developed awareness on the consumption of such foods, the underdeveloped distribution channels, specialized shops for this type of food is small, the higher the price of these products, as well as underdeveloped and widespread production.

Important methods for achieving sustainability in agriculture

One of the goals of the sustainable agriculture movement is to create farming systems that mitigate or eliminate environmental harms associated with industrial agriculture. That aim can be realized only in flexible cultural practices in real agroecological conditions (different regional characteristics, soil types, adapted cultivars for low-input or organic production). The transformation from conventional to sustainable organic field crop technology production requires changes and adaptation of many cultural practices (Kovacevic et al., 2000). Organic production is very specific in this respect must be for alternative small grains crops to develop appropriate supporting technology based on respect for ecological principles (Pearson et al., 2004). Republic Serbia has significant heterogeneous natural resources and favorable conditions for agricultural production that can meet the basic requirements for the establishment of organic agricultural production, due to lower land and water pollution due to less application of pesticides and other chemicals. This production, under our conditions in Serbia, is still modest due to the existing market restrictions. However, when it comes to organic production of cultivated and it is necessary to choose the type of field crops that do not have normal use (alternative) that would be suitable for such production (Sinebo et al, 2002; Kovacevic et al., 2007). Each of these crops has the botanical characteristics, needs for different growing factors and more like any other commercial crop. Some of these crops can be with local significance or in limited markets, and some may be of interest and on farms that are so oriented.

Intercropping

Intercropping is a type of mixed cropping and defined as the agricultural practice of cultivating two or more crops in the same space at the same time. The important reason to grow two or more crops together is the increase in productivity per unit of land (Oljača and Dolijanović, 2013). All the environment resources utilized to maximize crop production per unit area per unit time and risk may be minimized in intercropping system. Biological efficiency of intercropping can be better due to exploration of large soil mass compared to monocropping. This advaced agrotechnique has been practiced in past decades and achieved the goal in agriculture. There are some socio-economic, biological and ecological advantages in intercropping over monocropping (Dolijanović et al., 2005).

Successful intercropping needs several considerations before and during cultivation: intercropping afects vegetative growth of component crops, therefore have to consider the spatial, temporal and physical resources. Economically viable intercropping system largely depends on adaptation of planting pattern and selection of compatible crops. Cereal-legume intercropping system have potential to provide nitrogen depends of crop densities, light interception, crop species and nutrients (Oljača et al., 2000). Compatible crop selection is vital in intercropping practices. The choice of compatible crops depends on plant growth habitat, soil, light, water and fertilizer utilization. Cereal-legume intercropping increase the fixation of nitrogen by legumes, than different crop species in mixtures increase capture of growth limiting resources and different planting time of component crops can improve the resource utilization and reduce competition (Table 1).

Table 1. Grain yield (kg ha^{-1}) and LER of maize and beans in relation to different plant arrangement pattern and water regime (Oljača et al., 2000)

Year	Plant arrangement	Maize		Beans		LER	
		Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed
	1/3:2/3	5602	4578	1252	876	1.17	0.80
1994	1/2:1/2	8421	6037	1140	914	1.30	0.94
	2/3:1/3	8572	7706	633	434	1.01	1.11
	Sole crop	15060	13552	1472	1772	-	-
	S.E.	963.2		198.0		0.085	
	1/3:2/3	3943	3681	940	656	1.21	1.02
1995	1/2:1/2	7285	5999	938	494	1.54	1.06
	2/3:1/3	7428	6785	473	322	1.14	0.88
	Sole crop	10175	11375	1144	930	-	-
	S.E.	782.1		68.2		0.083	
	1/3:2/3	2089	1855	851	879	0.86	0.98
1996	1/2:1/2	3608	3339	734	436	0.97	0.85
	2/3:1/3	3738	4172	408	419	0.81	0.96
	Sole crop	6315	6647	1816	1258	-	-
	S.E.	329.8		160.6		0.045	
	1/3:2/3	3878	3371	1014	804	1.08	0.93
Mean	1/2:1/2	6438	5125	937	614	1.21	0.95
1994-	2/3:1/3	6579	6221	505	392	0.98	0.99
1996	Sole crop	10516	10524	1477	1320	-	-

S.E.-standard error; D.F.=24

This system also allowed the cereal grain yield in intercropping to exceed that in monoculture as has been the case for maize in our experiment. The average LER (Table 1) was higher than 1 only in 1/2:1/2 mixture (LER=1.21) on irrigated plot. The most productive

maize-beans intercrop was on irrigated plot in 1/2:1/2 mixture (LER=1.54). Other mixtures (1/3:2/3 and 2/3:1/3) showed advantage over sole crops under irrigation (LER=1.21, 1.14). The optimal spatial arrangement in our experiment was a single row of maize and two rows of beans (1/2:1/2 mixture). Under favorable conditions (irrigated plots or wet season) intraspecific competition appears to be more intense than interspecific competition in maize-beans intercropping system. The culture of beans in mixture with maize probably costs a small farmer very little more effort, than the production of a sole stand of maize.

Cover crops

Modern society, as mach as it could must be related to sustainable management of renewable natural resources trough ecologicaly based agricultural development. An ecological production management system that promotes and enhances biodiversity, biological cycles, and soil biological activity should be based on minimal use of „off-farm“ inputs and on management practices that restore, maintain, or enhance ecological harmony (Dolijanović et al., 2013). Increasing environmental problems and big concern on health issues has driven to development of new techniques and systems to deal with weeds, pests and diseases. Cover crops being often used to design new strategy that preserves farm natural resources while remaining it’s cost-effectivity.

Cover crops are very important, especially with regards to the sustainability of agricultural production, and the term cover crops involves a number of different measures of soil under vegetation (winter cover crops, green manure flies, living mulches (cover crops), sowing of fodder crops after the main crop (subsequent crops, etc..), as the intention of maintaining or increasing the organic matter in soil, improve soil physical properties (structure, water regime, etc..), accumulation of nitrogen legumes, improved microbial activity in soil, suppress weeds, and generally raising soil fertility.

The term "cover-crop," which, until 1893, was not distinguished from "catch-crop," or from "green-manure crop," is now applied to a crop grown to prevent injury and losses to soils, and either directly or indirectly to improve them, and often to afford protection to trees or other plants, rather than to secure the proceeds or products of the crop itself. Cover crops can have numerous other benefits including improvement of soil quality, pest management, fertility management, water availability, landscape diversification, and wildlife habitat. Cover crops are of interest in sustainable agriculture as many of them improve the sustainability of agroecosystem attributes and may also indirectly improve qualities of neighboring natural ecosystems. Cover crops can also improve soil quality by increasing soil organic matter levels through the input of cover crop biomass over time. By reducing soil erosion, cover crops often also reduce both the rate and quantity of water that drains off the field, which would normally pose environmental risks to waterways and ecosystems downstream.

Cover crops can play an important role in managing weeds by shading and interfering with weed germination and establishment. Among cereals, it is known that rye produces allelochemicals, naturally occurring compounds that can control or suppress weeds.

Once researchers find the appropriate combination of maize and ground cover, they believe yields will not be impacted, and soil quality will be maintained. Nevertheless, cover crops can also become weeds and must be carefully managed to prevent it’s competitivity toward main crops regarding soil moisture, nutrients etc. The possibility to reduce weediness on the basis of the increased crop competitive abilities by growing high yielding hybrids that "tolerate" a higher plant density depends on traits of each hybrid and climatic conditions in the specific growing region (Williams et al., 2007).

Growing cover crops is one extremely important tool for the appropriate management of weeds in long-term weed control under sustainable and organic agricultural systems. Perceived benefits of the alternative technology over conventional one should considered mostly in terms of grain yield of the main crop. Currently, living mulch in spring-sown cover

crops has had positive impact on lower weediness, and oppositely, negative impacts on sweet maize yield. The main crop of sweet maize was not competitive enough with ground cover, mainly because of limited soil moisture and nutrients, especially between the rows of sweet maize being possessed by living mulch (Table 2).

Weeds species were weaker competitor in this situation. The highest total fresh weight was 834. 1 g m^{-2} (conventional system) in 2011 and 728.8 g m^{-2} in 2012 while the lowest fresh weight was measured in hairy vetch (winter cover crops) and common vetch (spring cover crops) in both years. By covering bare soil with straw (organic mulch) weediness becoming somewhat higher comparing plots among winter and spring cover crops, even though sweet maize yield significantly was higher using this system of growing. In addition, cost inputs were reduced, but no other common benefits in the long term were found on winter and spring cover crops (increase of organic matter, increase of biodiversity, etc.). Among all variants with winter and especially with spring cover crops, plot weediness of main crop was lower comparing to control variants in both years of investigation.

Weeds represent one of the major threats to crop production in sustainable and organic farming systems. The risk of high weed infestations is not only yield reduction of the main crop but also the decrease of the commercial quality and the feeding palatability of main crops (Rahman et al., 2006) and enrichment of the soil seed bank of weeds (Buhler, 1999), which may cause severe weed infestation in subsequent crop production (Uchino et al., 2009).

Table 2. The growing season (A) and cropping system (B) effects on weed infestation and grain yield of sweet maize (Dolijanovic et al., 2013)

Cropping system (B)		Fresh biomass (g m^{-2})		Air dried biomass (g m^{-2})		Yield (t ha^{-1})
		2011	2012	2011	2012	2011
Winter cover crops and mixtures (dead mulch)	Common vetch	291,4	255,1	70,2	79,3	8,84
	Hairy vetch	288,6	262,1	69,7	74,2	9,98
	Oats	311,6	302,3	78,8	80,7	9,07
	Fodder kale	301,0	296,5	80,2	78,7	8,32
	Common vetch+oats	310,1	307,4	90,6	91,1	8,72
	Hairy vetch+oats	304,5	303,9	94,2	101,8	8,61
	Average	301,2	287,9	80,6	84,3	8,92
Control treatment	Organic mulch	381,1	326,7	102,3	85,4	10,00
	Conventional system	834,1	728,8	121,1	132,6	8,09
	Average	607,6	527,7	111,7	109,0	9,05
Spring cover crops and mixtures (living mulch)	Common vetch	212,6	198,4	56,9	59,8	7,61
	Oats	304,8	299,7	65,2	61,8	7,49
	Common vetch+oats	291,3	289,7	70,2	55,6	6,21
	Average	269,6	262,6	64,1	59,1	7,10
	Average	392,8	359,4	85,5	84,1	8,36

Fresh biomass LSD	A	B	AB	Air dried biomass LSD	A	B	AB	Yield of grain LSD	
0,05	0,52	1,21	1,71		0,69	1,42	2,04	0,05	0,41
0,01	0,71	1,66	2,35		0,91	1,83	2,63	0,01	0,57

The highest yield of sweet maize was obtained in the variant with dead organic mulch (10.00 t ha^{-1}), primarily due to the fact that for its decomposition was significantly more time alone and the planting of corn was thus greatly facilitated. The lowest yield was obtained following the conventional system (8.09 t ha^{-1}) as well spring cover crops. Yield of sweet maize in this study was below average yields in similar experiments (Dolijanović et al., 2012), and the main reason was the way of growing. The variants covered by dead mulch, and

especially variants being covered by living mulch mixtures gave higher yields of biomass and consequently lower grain yield of sweet maize as a main crop.

Challenges for plant breeders

Breeding programs dedicated to organic agriculture would focus on traits including improved nitrogen and nutrient efficiency, adaption to soil microbes, improved competitiveness against weeds and resistance to insects and diseases currently controlled with chemical pesticides with the incorporation of these traits into high yielding cultivars, organic agriculture will be better equipped to realize its full potential as a viable alternative to conventional agriculture (Murphy et.al., 2007; Przystalski et al., 2008). The transition to new technologies with lower investments, as the case in the organic production of winter wheat and other grain alternative is unthinkable without the new varieties. The initial approach and criteria in the ideo/types varieties design for such a change to the conditions must be different from the present.

New varieties must have a greater resistance to abiotic and biotic stress conditions, more efficient uptake of mineral nutrients and better exploit of the existing environmental conditions. Since the problems of weeds in organic crop production are more pronounced if it is the initial criteria, it is certain that sorts incurred by this means should be selected, based on other grounds (Kovacevic et al., 2007; Kovacevic et al., 2009; Berenji, 2009).

Many alternative grains may well be successful in our environmental conditions as indicated by our research (Kovacevic et al., 2014). Each genotype has a morphological characteristic, the need for different vegetation factors, usage, etc. like any other commercial crop. Placing the individual genotypes in terms of organic cultivation technology, we have examined their response through measurement of morphological and productive traits. Test results of grain yield of different wheat genotypes alternative small grains are shown in Table 3.

Table 3. The effect of fertilizer on Grain yield of small grain genotype in relation with different fertilizers, t ha^{-1}

Year/	2006/07			Average	2007/08			Average	Average
Genotype	F_0	F_1	F_2	G	F_0	F_1	F_2	G	
G_1	3.13	3.91	3.38	3.47^{a}	4.63	6.53	5.65	5.60^{a}	4.54
G_2	2.25	2.59	2.96	2.60^{b}	3.49	5.40	4.44	4.44^{b}	3.52
G_3	3.47	4.33	2.81	3.54^{a}	3.75	6.10	4.84	4.89^{c}	4.22
G_4	2.52	3.35	2.62	2.83^{b}	3.78	5.22	3.97	4.32^{b}	3.57
Average F	2.84^{b}	3.55^{a}	2.94^{b}	3.11	3.91^{b}	5.81^{a}	4.73^{c}	4.81	3.96

G-genotypes (G_1-NS 40 s, G_2 -Bambi, G_3 -Nirvana, G_4 -Durumko); F-fertilizers (F_0 control, F_1 organic + microbiological fertilizer, F_2 microbiological fertilizer); Means that columns followed by the same letter are not significantly different according to Fisher’s protected LSD values (P=0.05)

Factorial analysis of variance has showed that grain yields significantly depend on the chosen fertilizer. Combined application of organic fertilizer in the fall and microbial in the spring, the highest average yields of alternative wheat were obtained regularly. The yield obtained by this variant, compared to the other two variants of fertilization were highly significant.

From the genotypes, the highest yields were obtained by growing commercial varieties NS-40S, especially in terms of combined application of organic and microbial fertilizers in the second, a better year of study. Spelt wheat is second genotype by its yield, with a note that the yield of this genotype in the control plots was always the lowest.

Future directions

Sustainability is a test of time: an agroecosystem that has continued to be productive for a long period of time without degrading its resource base - can be said to be sustainable. How can a sustainable system be designed when the proof of its sustainability remains always in the future? Generating the knowledge and expertise for doing so is one of the main tasks facing the science of agroecology today, and is the subject to which this chapter is devoted.

Serbia as a country has variety of geographic, climate, natural and cultural heritage. Mountains of Serbia are part of one of 6 biodiversity centers of temperate climate. Extremely in danger, these vulnerable areas require special treatment that would provide whole network of life protection, instead conventional protection of nature. Optimal model of community development for these territories is in the framework of integral rural development strategy and organic agricultural production which is part of this concept. Absolutely essential condition for starting of organic production is obeying the low and other legal acts, which provide in details selection of plots and other conditions. Organic agriculture is very suitable for natural resources and protected areas management: in national parks, nature reserves, water supply zones and other endangered and sensitive parts of the country. Modern cities will have the need for using different ecological trends in architecture, touristic attractions, permaculture - modern landscape design, where the multifunctionality of agriculture will be seen in the best way.

Ministry of Agriculture with serious extension service, cooperatives and different specialized associations should help our agricultural producers to solve many problems that they face in their production on the field. They have to provide necessary prosperity and economic security for life on the land.

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