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ANTIOXIDANTS IN SOYBEAN AND SUNFLOWER GRAIN*

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SUMMARY: The objective of this study was to examine differences in antioxidants content: phytate, phenolics, free thiolics (PSH) and glutathione (GSH) in seeds of 7 soybean varieties and 10 sunflower lines with aim to signify their nutritive quality, valuable for further breeding process. The variations between soybean varieties in phytate content were minor, while el/7 was sunflower line with lowest phytate content, which could be used for program breeding of low phytate grain. The relative high phytate and phenolics content was present in Laura seeds, as well as lowest PSH and GSH content. Generally, the higher content of phenolics were in sunflower seeds, what could be considered as negative atribut from nutritive point of view. The highest PSH content was observed in soybean seeds of Nena and Olga. Lower PSH and GSH content was noted in sunflower seeds (down to 4 and 7 times, respectively), compared to soybean. The soybean seeds have potentially better antioxidative potential, compared to sunflower, owing to multiple higher PSH and GSH content and lower level of phenolics. Soybean variety Olga is accenuated as high in PSH and GSH, as well as sunflower line l4/ru, which had higher PSH and particulary GSH level, with lower phytate and phenolics content, as possible antinutrients.

Key words: *phytate, phenolics, thiolics, glutathione, soybean, sunflower.*

INTRODUCTION

Antioxidative substances are very important nutritive factor, responsible for seed longevity (Ramarathnam et al., 1986). One of the most important components for phosphorus storage is phytate (Lott et al., 2000), which, from one side represents antinutritive factor, due to its indigestibility for monogastric organisms, and from other side, has positive role as an antioxidant and anticancerogenic agent. Malenčić et al. (2007) un-

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derlined phenolics as bearers of antioxidative activity in soybean seeds, since the seeds with low phenolic's content have poor antioxidative activity, too. Meanwhile, phenolics react with proteins in sunflower seeds, threatening its quality (Gandhi et al., 2008).

One of the most important antioxidative and nutritive factors are protein antioxidants, i.e. free thiolic groups, which participate in stress prevention in seeds, either in green parts of plants (Chernikova et al., 2000; Santos and Rey, 2006). From this point of view, special attention is given to glutathione, as the one of the crucial "free radical" trappers. Free thiolics have important role in soybean and sunflower grain, since they prevent protein components from degradation (De Paula et al., 1996; Awazuhara et al., 2002).

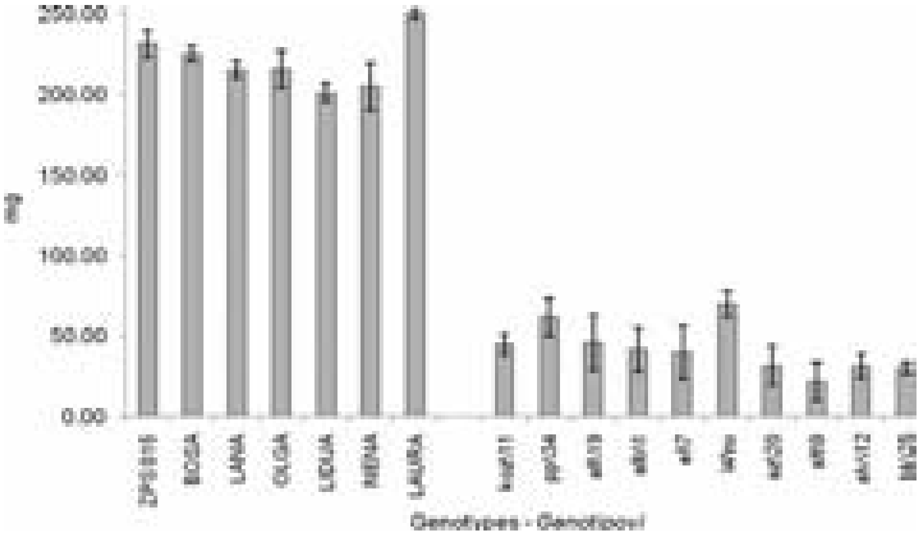
Therefore, the content of phytate, phenolics, free thiolics and glutathione in grain of 7 ZP soybean varieties and 10 sunflower lines were examined in aim to signify their nutritive quality and importance in future breeding program.

MATERIAL AND METHODS

The content of antioxidative substances was analysed in grain of 7 ZP soybean varieties ZPS 015, Lidija, Laura, Lana, Olga, Nena and Bosa) and 10 sunflower lines (koz/11, all/19, bk/25, az/20, alv/12, alt/9, el/7, l4/ru and alb/1). The seeds originated from 2009 and was produced in the experimental field of Maize Research Institute in Zemun Polje. The pericarp was previously removed from sunflower seeds. The soybean and sunflower grain was ground on Tecator Knifetec 1095, then the oil was removed by extraction with petrol-ether (40 – 60 °C) during 12 hours. From grain prepared in such manner, the extraction of antioxidative substances was performed with bidistilled water. The content of particularized antioxidans was analysed: total soluble phenolics, by method of Simić et al. (2004), total soluble thiolics (PSH), by method of deKok et al., (1981), total phytate by modified method of Jočić (1996), while the total gluathione (GSH) was determined after extraction with 5% trichloracetic acid, by method of Sari Gorla et al. (1993). Over against, the content of analysed antioxidants, the was similarity between genotypes was determined b, PATH analysis (Wright, 1923).

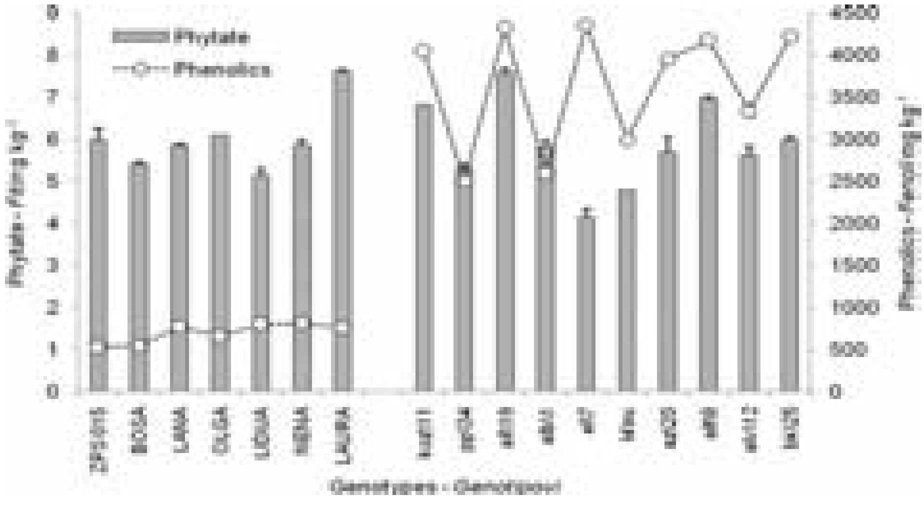
RESULTS AND DISCUSSION

The phytate presents important antioxidant in plants, irrespective to its antinutritive character (Lott et al., 2000). Phytate content differed among soybean varieties in lower degree, to 32% (Graph 2). The highest phytate level was observed in grain of Laura, variety lacking in Kunitz trypsin inhibitor (Perić et al., 2009). On the other hand, a variation of phytate content among sunflower lines was up to 45%. Thereby, it was necessary to emphasize el/7 as line with lowest phytate level. This genotype could be used as valuable source in further breeding programs for low-phytate sunflower hybrids, first of all from the reason of negative aspect of high phytate level in sunflower grain (De Paula et al., 1996; Hídvégi and Lásztity, 2002). Unlike soybean, where positive correlation between seed size and phytate content was observed (R = 0.80), the correlation was negative at sunflower and it was insignificant (R = -0.34).



Graph 1. The seed weight of different soybean varieties (ZPS015, BISA, LANA, OLGA, LIDIJA, NENA, LAURA) and sunflower lines (koz/11, pp/34, all/19, alb/19, el/7, l4/ru, az/20, alt/9, alv/12, bk/25); average value ± SD

Grafik 1. Masa semena različitih sorti soje (ZPS015, BISA, LANA, OLGA, LIDIJA, NENA, LAURA) i linija suncokreta (koz/11, pp/34, all/19, alb/19, el/7, l4/ru, az/20, alt/9, alv/12, bk/25); prosečna vrednost ± SD

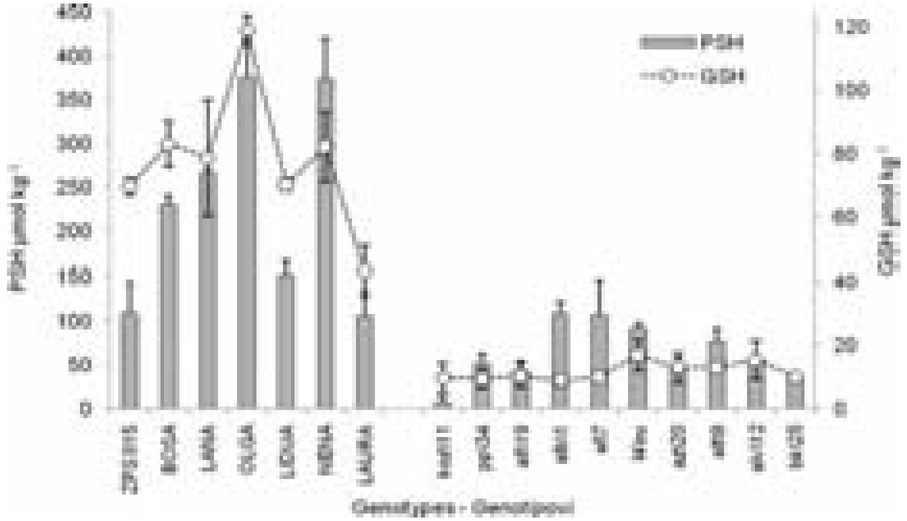


Graph 2. The content of phytate and phenolics in grain of the different soybean varieties (ZPS015, BISA, LANA, OLGA, LIDIJA, NENA, LAURA) and sunflower lines (koz/11, pp/34, all/19, alb/19, el/7, l4/ru, az/20, alt/9, alv/12, bk/25); ± SD

Grafik 2. Sadržaj fitina i ukupnih fenola u zrnu različitih sorti soje (ZPS015, BISA, LANA, OLGA, LIDIJA, NENA, LAURA) i linija suncokreta (koz/11, pp/34, all/19, alb/19, el/7, l4/ru, az/20, alt/9, alv/12, bk/25); ± SD

As well, the content of total soluble phenolics varied among soybean varieties to 35%. The group of 4 varieties with higher content of phenolics in grain was seceding:

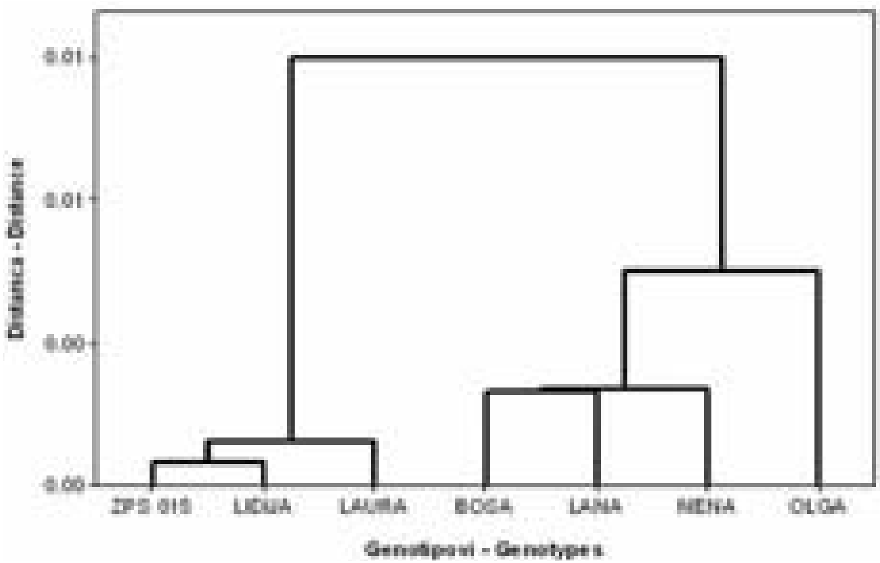
Lana, Lidija, Nena and Laura, which had 758 – 805 mg kg^{-1} (Graph 2). Considering Laura, as variety with largest seed and highest level of phenolics is aparted from other varieties, the theory of Lee et al. (2008), about negative correlation between grain size (Graph 1) and phenolics content in soybean grain could be confirmed. Beside the high level of phenolycs and phytate in Laura grain (Graph 2), it was important to underline that lowest level of PSH i GSH was present, too (Graph 3) indicating different anti-oxidative profile of this variety, i.e. relatively low antioxidative potential of its protein component in grain. Generally, the higher content of phenolics was present in sunflower grain, while the varying among lines was up to 42%. From the nutritive point of view, higher phenolics level, as it was in grain of koz/11, all/19, el/7 alt/9 and bk/25 is negative characteristics, since it has been responsible for changes in protein quality during the procession of sunflower meal (Gandhi et al., 2008). Ramarathnam et al. (1986) are underlining positive impact of phenolics on rice seed longevity.



Graph 3. The content of thiolics (PSH) and glutathione (GSH) in grain of the different soybean varieties (ZPS015, BISA, LANA, OLGA, LIDIJA, NENA, LAURA) and sunflower lines (koz/11, pp/34, all/19, alb/19, el/7, l4/ru, az/20, alt/9, alv/12, bk/25); average value ± SD

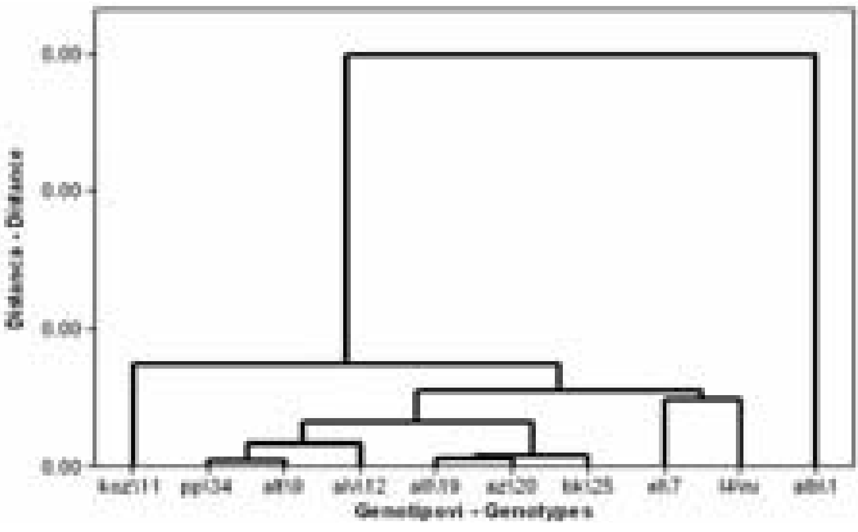
Grafik 3. Sadržaj tiolnih grupa (PSH) i glutationa (GSH) u zrnu različitih sorti soje (ZPS015, BISA, LANA, OLGA, LIDIJA, NENA, LAURA) i linija suncokreta (koz/11, pp/34, all/19, alb/19, el/7, l4/ru, az/20, alt/9, alv/12, bk/25); prosečna vrednost ± SD

The free thiolic groups (-SH) are of importance as anti stress factor (Chernikova et al., 2000; Awazuhara et al., 2002). The highest PSH content was observed in grain of Nena and Olga (Graph 3). Additionally, the highest GSH value was noticed in Olga's grain, which could provide the high anti oxidative potential of this variety, based on thioredoxines (Santos and Rey, 2006). Then again, low PSH i GSH content in Lidija grain could point to low thioredoxine's activity in trapping of free radicals. Other than soybean, 4 times lower PSH and 7 times lower GSH content was noted in sunflower grain. Torres et al. (1996) are emphasizing that GSH is the most important antioxidant in sunflower grain. In regard to that fact alb/1, el/7 i l4/ru were identified as the lines with twice higher PSH level, compared to other lines. It is important to underline line l4/ru, which had the highest GSH level, too.



Graph 4. Cluster analysis dendrogram for content of analysed antioxidants in soybean grain (ZPS015, BISA, LANA, OLGA, LIDIJA, NENA, LAURA)

Grafik 4. Dendrogram klaster analize za sadržaj analiziranih antioksidanata u zrnu soje (ZPS015, BISA, LANA, OLGA, LIDIJA, NENA, LAURA)



Graph 5. Cluster analysis dendrogram for content of analysed antioxidants in sunflower grain (koz/11, pp/34, all/19, alb/19, el/7, l4/ru, az/20, alt/9, alv/12, bk/25)

Grafikon 5. Dendrogram klaster analize za sadržaj analiziranih antioksidanata u zrnu suncokreta (koz/11, pp/34, all/19, alb/19, el/7, l4/ru, az/20, alt/9, alv/12, bk/25)

Considering the total content of analysed antioxidants, a cluster analysis classified 7 soybean genotypes into two groups: first subcluster composed of cultivars ZPS015, Lidija and Laura and second group comprised of cultivars Bosa, Lana, Nena and Olga

(Graph 4), which were characterised by high level of protein antioxidants (Graph 3). Sunflower lines (Graph 5) were clustered into several smaller groups, while two lines were outliers: koz/11 with the lowest level of protein antioxidants (Graph 3) and relative high content of phenolics (Graph 2), and alb/1, with the highest content of phenolics and PSH.

CONCLUSION

Based on obtained results, it could be concluded that soybean grain has potentially better antioxidative potential, in relation to sunflower, owing to multiple higher content of PSH and GSH, as well as lower level of phenolics. Special accent is given to soybean variety Olga, which has high PSH and GSH content and sunflower line l4/ru, which had higher GSH and PSH content, too, with lower level of phytate and phenolics, as potential antinutrients.

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ANTIOKSIDANTI U SEMENU SOJE I SUNCOKRETA

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Izvod

Cilj ogleda je bio da se ispitaju razlike u sadržaju antioksidanata: fitina, fenola, slobodnih tiola i glutationa u semenu 7 ZP sorti soje i 10 linija suncokreta i time ukaže na njihov nutritivni kvalitet i značaj za dalji proces selekcije. Kod soje nije bilo znatnijih variranja u pogledu sadržaja fitina, dok se kod suncokreta izdvaja el/7, kao linija sa najnižim učešćem fitina, koja bi mogla poslužiti u postupku oplemenjvanja niskofitinskih hibrida suncokreta. Kod Laure je pored relativno visokog sadržaj fenola i fitina bio prisutan i najniži sadržaj PSH i GSH. Kod suncokreta je generalno bio prisutan znatno veći sadržaj fenola u zrnu, što je sa nutritivne tačke gledišta negativno. Kod ispitivanih sorti soje, najveći sadržaj PSH je bio kod Nene i Olge. U semenu suncokreta je prosečno bilo 4 i 7 puta manje PSH i GSH. Seme soje poseduje potencijalno bolji antioksidativni potencijal u odnosu na suncokret, zahvaljujući višestruko većem sadržaju PSH i GSH i nižem udelu fenola. Posebno se ističe sorta soje Olga sa visokom sadržajem PSH i GSH, kao i linija suncokreta l4/ru, koja je imala veći sadržaj PSH, a posebno GSH i niži udeo fitina i fenola, kao potencijalnih antinutritiva.

Ključne reči: fitin, fenoli, tioli, glutation, soja, suncokret.

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ORGANIC CEREAL PRODUCTION - OPPORTUNITY FOR AGRICULTURE IN SERBIA*

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SUMMARY: Areas under certified organic production in the world are constantly increasing. The most present plant species in organic production in the world are cereals and forage crops, and from permanent crops - olives, fruits and grape vines. Trend of constant increasing in human population imposes a constant need to increase the production of small grain, while the specific nutrition requirements suggest use of alternative grain in addition to conventional. These usually involve species that are produced in relatively small areas, whose production is in most cases labor intensive, but from the unit area provides greater profit compared to the production of conventional crops. Organic production in Serbia is recent date compared with EU countries, and it is based mainly on the production of vegetable and fruit. Since the cereals are most represented in organic production in the world, our goal is to present the basic recommendations and the possibilities of their growing in these systems in our country. Special accent was placed on the specificity of next alternative plant species: durum wheat, spelt, millets, grain sorghum and buckwheat.

Key words: *organic production, small grains, alternative crops*

INTRODUCTION

According to the *International Federation of Organic Agriculture Movements (IFOAM)*, *«Organic agriculture is a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects».* Organic produc-

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tion is based on basic agroecological principles, by including household management of resources with respect for all elements of environmental protection. In recent decades, there is intensively developed awareness that the quality of food and raw materials is necessary to monitor, improve and regularly control, more than ever *(Malešević et al., 2008).* Besides that, accent is put on the control of use of various agrochemicals, whose improper application negatively affects agro- and natural ecosystems, and directly or indirectly influences people's health (*Malešević et al., 2009).* According to *Bavec and Bavec (2007),* in human- and environment-friendly crop production and food processing systems, use of chemicals (fertilizers, pesticides, pharmaceuticals, growth regulators, and unhealthy additives), gene modified organisms (GMOs), and non-resistant cultivars to diseases are maximally reduced.

Thus, the notion of organic agriculture usually refers to the way of growing plants without using mineral fertilizers and pesticides *(Kovačević and Oljača, 2005).* Long term maintenance of soil fertility is of crucial importance, and it is obtained mostly by applying integral and preventive measures. Organic production is based on the principles of agroecology *(Oljača, 2001; Molnar et al., 2005; Milošev and Šeremešić, 2007),* and it is integral part of sustainable agricultural development which uses scientific knowledge regarding the natural laws and establishment of environment protection principles, for production of healthy and safe food (*Lotter, 2003; Lazić and Malešević, 2006).*

Due to a number of advantages in comparison to other systems of growing plants, the areas under certified organic production are increasing every year. Organic production methods have been applied in over 150 countries in the world, on over 35 million ha, from which 8,2 (about 23%) million ha are in Europe. The most common plants in organic arable land (total 4,6 million ha) are cereals (~2 mill. ha, or 44%; the countries with the largest areas in 2008 are Italy, USA and Germany) and field fodder crops (32%), and among perennial plants - olives, fruit and grape vines *(Source: FiBL & IFOAM Survey 2010; most data collected are from 2008).*

As cereals are the most common species in organic production in the world, our goal is to point out basic principles of their cultivation, with a special review of alternative grain species which are becoming more and more popular in organic production. According to *Bavec and Bavec (2007)*, the introduction of alternative crops into rotation will contribute to more natural production systems. Alternative crops (old, ancient, neglected, disregarded, or new) can also help to reduce natural over-sensitivity by sowing more resistant genotypes to plant diseases, increasing the population of natural predators, changing weed population, and helping us to produce healthy food without synthetic pesticides.

The basic principles of organic production in field crops management

Successful farming, as well as *organic production of field crops*, is based on *soils* rich in organic matter, with a good structure, water-air properties and ample in living microorganisms, wich represents a basis for production of healthy plants. This type of soil is good for providing plants with water and elements of mineral nutrition which occurs due to the activity of soil microorganisms, and can be assured by the proper manipulation of harvest residues *(Malešević et al., 2009b; Latković et al., 2009).* Fixation of atmospheric nitrogen can be successfully done on such soil as well as normal circulation of matter, including organic matter from farm and fertilizers permitted in this kind of production *(Malešević et al., 2009a)*. Organic farming is founded on the idea that soils with sufficient organic matter content, good structure, ample and variegated in living microorganisms can provide a base for healthy crops. *Đurić et al. (2008)* refers that application of manure as a result had an increase of microbial C-biomass by 100% in soil profile from 0-60 cm. During the organic maize production, input of manure induced the increase of number of investigated group of microorganisms in soil.

Crop rotation has the crucial role in achieving goals of organic production *(Milošev and Šeremešić, 2004)* because it systematically harmonizes and optimizes all agrotechincal measures. The impact of *previous crops (precrops)* is manifested through consumption of water and nutrients, quantity of harvest residues, time of leaving the field etc. Pre-crops also dictate the method and intensity of soil cultivation, as well as dynamics of fertilizing. Thus, crop rotations have a great importance and potential in the development of integral systems of plant production, especially in the systems of organic farming.

In order to preserve soil fertility potential, it is important to carefully choose which annual and perennial plant species will be grown, therefore, crop rotation is most important agrotechical measure in organic production *(Lazić and Malešević, 2004; Šeremešić and Milošev, 2006)*. Organic production has greater capacity for improvement of soil quality in comparison to the conventional production systems *(Karlen et al., 1997)* because it uses different crop rotations, organic fertilizers and smaller intensity of soil cultivation *(Liebig and Doran, 1999).* In the organic production system, *forage and leguminous crops* should be more present in the structure of crop rotation. Crop rotations should include growing of *stubble and cover crops, intercrops, companion- and catch crops,* as well as other various modifications. By sowing inter- and cover crops, organic production can be remarkably improved. The main goal of growing intercrops is not the yield, but primarily protection of agroecosystems, decreasing or avoiding mineral fertilizers, pesticides and increase in biodiversity *(Ćupina et al., 2004).*

Release of *nutrients* into easily accessible forms to plants is directly affected by the activity of microorganisms, and their activity is conditioned with temperature and presence of water and air. Nutrient management in organic systems is based on fertility-building leys that fix atmospheric nitrogen, combined with the recycling of nutrients via bulky organic materials such as farmyard manure and crop residues, and with only limited inputs of permitted fertilizers *(Gosling and Shepherd, 2005). Soil fertility control,* which includes measuring of content of easily available nutrients in the soil, must be included in this segment of organic production *(Malešević, 2008b).* Amount of nutrients in the soil and their availability depend to a great extent on fertilizing system before conversion to the organic production as well as during the conversion period *(Čuvardić et al., 2006).*

Organic fertilizers are irreplaceable when it comes to soil revitalization, i.e. to the improvement of its physical, chemical and biological characteristics. They are important in all concepts of sustainable and organic agriculture as those concepts almost completely exclude application of mineral fertilizers *(Čuvardić, 2006).* Also, a significant amount of fresh organic matter is introduced by plowing down *green manure*, and *leguminous crops* which can enrich soil by nitrogen. Green manuring improve soil physical and water characteristics, and above all, enhance structure and increase biological activity, as significant factor of soil fertility. Tasks of organic management system are to maximize the contributions of on-farm resources such as animal manures, composts, and green manures to soil fertility. However, purchased off-farm nutrients - including mineral fertilizers, fortified composts, and plant and animal meals - may be necessary to ensure adequate nutrient availability during transition to an organic program *(ATTRA, 2003)*.

Special attention in organic crop production should be devoted to *nitrogen*, as major yield bearer *(Malešević, 1987)*. Animal manures and legumes are two major sources of nitrogen in organic systems. Legume cover crops, plowed down to provide green-manure nitrogen, also contribute to soil tilth and increase of organic matter content. During decomposition, legumes can provide 50 to 170 kg N ha^{-1}. Small grains can also receive supplemental nitrogen from crop rotation patterns that include perennial legumes like alfalfa and clover *(Sullivan, 2003)*. Plant demands for nitrogen can be compensated besides symbiotic, with the unsymbiotic nitrogen fixing bacterias. Possibilities for use of useful microorganisms in organic agriculture are great, especially as bio-fertilizers and biofertilizators *(Đorđević, 2005)*. Nowadays, for such intentions there are numerous microbiological preparations in Serbia *("Nitragin", "Azotofiksin", "Azotobakterin")*. Leguminous plants that fix and accumulate nitrogen in soil should be grown in rotation with plant species that consumes greater amounts of this nutrient.

Native *phosphorus and potassium* fertility may be enhanced using animal manures and conserved through good management of cover crops and crop residues. Rock phosphate can serve as an alternative or supplementary phosphorus source when necessary *(Sullivan, 2003)*.

The right selection of adaptable cultivars and hybrids of agricultural plants for specific ecological conditions, as well as quality and health conditions of seed material, represents one of the most important pre-conditions for successful crop production. Moreover, the choice of the variety and hybrids must be founded on precise evaluation of consumptive habits in the specific market as well as on the expected financial results. Modern breeding technologies offer great choice of varieties and hybrids of field crops species suitable for organic growing. According to *Berenji (2009),* creation of varieties with an outstanding resistance towards the most important diseases and pests, and adapted to the conditions of low-input, rational investments as well as on abiotic stresses - represent a special challenge in breeding.

Crop density should be adjusted to the characteristics of variety (height, tillering, branching, yield structure etc.) and to the chosen methods of plant protection against weeds and diseases. Crops with lower density have a better developed root system and they are more immune to stresses. Moreover, in such lower density crops, the possibility of mechanical control of weeds is much simpler. Crop density should be also formed on the basis of available water quantities.

In a dynamic and highly sensitive agroecosystems in which an organic production is carried out without the use of synthetic preparates, for suppression of diseases, pests and weeds it is necessary to develop and promote natural mechanisms as self-regulatory function of their populations. In the ecological croping systems, the occurrence of different weed species was significantly higher and similarly in this system the weight of weed dry matter was much higher than in the integrated one *(Týr and Lacko-Bartošová, 2007)*. Weed control in organic agriculture should be based on long-term strategy that includes prevention of their growth, exhaustion and destruction.

Preventive measures in suppressing weeds are very important factor in efficient protection in all systems of plant production. They include all measures whose goal is protection of field from weeding, which refer to all those measures that stop occurrences of weed seeds and their vegetative organs in the field *(Kovačević i Momirović,* *2008)*. From all direct agrotechnical measures used in weed control; the most important are all methods and systems of field cultivation, fertilization, sowing, care measures, and especially plant production systems where crop rotation is playing a important role. Also, growing resistant varieties and hybrids, utilisation of alelopathy, passive barriers and monitoring of weather forecast, have significant place in efficient plant protection in organic production.

Harvest and crop reaping are defined and determined by plant growing systems. The moment of harvest is also determined by dynamics of plant maturation, forming of the quality of products, methods of drying and storing.

Organic small grains production

Growing of small grains organically means using sustainable methods that exclude the use of standard artificial fertilizers and other synthetic matter like pesticides, preservatives, and growth regulators. The group of small grains suitable for organic production includes wheat, barley, oats, rye and triticale (*Triticosecale*). From *Triticum* genus, because of their high nutritive values, more and more interesting are *Durum (hard) wheat*, *Spelt wheat*, *Einkorn*, *Emmer, Kamut (Khorasan wheat)* and many others. By knowing requirements of these species to environmental conditions is extremely important when choosing the appropriate growing technology. The role of people here primarily refers to mitigate the negative effects of climate extremes on plants, especially by the right choice and on-time applying of agrotechnical measures.

Ecology and biological characteristics of small grains. Small grains have winter and spring forms. Each species has great number of varieties, and some of them have sub-species and ecotypes. If huge number of varieties is added, it is clearly why small grains have the widest growing area in the world. Small grains belong to the species of moderate climate. Biological temperature minimum for germination is 4-5 °C, and for the formation of generative organs and maturation about 10-12 °C. Their production optimum for germination is 6-12 °C, for forming vegetative organs 12-16 °C, for generative ones 16-20 °C and for maturation 16-22 °C. Higher temperatures (over 30 °C) significantly decrease vegetation period of small grains, by decreasing yield. Barley endures them best, and rye and oats the least. The relation towards low temperatures is extremely important for winter forms of small grains. In our conditions rye can endure even -25 to -30 °C without snow, triticale, spelt and common wheat -15 to -20 °C, winter barley and durum wheat up to -12, winter oats -10 to -12 °C, while spring barley and oats with minor damages can endure -6 to -8 °C. Relation towards low temperatures depends on the variety and growing stage.

All small grains require a continuous supply of water throughout the vegetation period. The optimal soil moisture for this species is around 60-80% of full field water capacity. Transpiration coefficients of small grains are ranged from 300-400 at barley, to 500-600 in oat and wheat. Critical periods regarding to water plants supply are periods from sowing to emergence; stem elongation to intensive growth and grain filling. Under the continental climate conditions, reserves of winter precipitation in soil are very important. Without them, only with vegetative precipitation, high yields cannot be achieved.

Good yields of small grains can be achieved in the fertile, humous *soils*, mostly by neutral reaction, pH 6-7. Rye can endure acid reaction up to pH 5,5, triticale 5,5-6, and some wheat varieties can endure pH values about 8. It is very important that soils are rich in organic matter and that they have great microbiological activity. These soil characteristics are crucial for dynamics of adopting nutritive matter in small grains.

Details of **small-grain production practices** - such as planting dates, seeding rates, varieties, and harvesting methods - vary widely among regions, but are largely the same for conventional and organic systems. Compared with conventional agriculture, where agrotechnical measures (cultivation, fertilization, plant protection etc.) can be individually planned and optimized, organic small grain production technology is more complex because of its expected cumulative effects *(Olesen, 1999, Kovačević et al., 1999).*

Variety selection. Variety or hybrid is the basis of high yield and quality of small grains. When selecting cultivars, great attention must be paid to their yield, yield stability and grain quality (especially from the aspect of nutritive value and possibility of 'healthy food' production), then their resistance to lodging, diseases and abiotic stresses *(Bedo and Malešević, 2001).* Also, it is important to know duration of vegetation period for specific variety, in order to avoid critical periods in which high temperatures may appear. Appropriate genotypes for organic production can be found among very rich collections of small grain varieties in Serbia. Modern breeding offers great opportunities for this selection, and in the existing 'gene banks' eminent older varieties convenient for systems of organic crop production can be found. Many of serious seed companies in the world started with production of organic seed of some grown species. In Serbia, possibilities for this kind of production were getting by adoption of Organic agriculture law *(Milovanović et al., 2009).*

Table 1: Needs of small grains for nutritive elements in kg t^{-1} and for adequate straw quantity (average values by various authors)
Tab. 1: Potrebe strnih žita za hranljivim elementima u kg t^{-1} zrna i odgovarajuću količinu slame (prosečne vrednosti date od strane više autora)

Small grain species – *Vrsta žita*	kg t^{-1} grains + straw* - *kg t^{-1} zrna + slama**				
	N	P_2O_5	K_2O	CaO	Mg
Wheat - *Pšenica*					
Winter - *ozima*	30	12	22	6	4
Spring - *jara*	32	12	24	4	3
Barley - *Ječam*					
Winter - *ozimi*	24	10	25	10	3
Spring - *jari*	20	10	21	10	3
Spring oats – *Jari ovas*	25	13	30	6	4
Winter rye – *Ozima raž*	25	11	25	8	3
Winter triticale – *Ozimi tritikale*	25	12	18	6	3
Durum wheat – *Durum pšenica*					
Winter - *ozima*	30	12	24	7	4
Spring - *jara*	34	15	24	7	3

**Given values vary ± 15-20% according to authors, growth conditions and yield height*

Small grains nutrients requirements. The adoption of elements of mineral nutrition in cereal begins after forming the 2 leaf of seedlings, when young plants transfer to autotrophic nutrition. The fertilization of small grains is based on their needs for NPK nutrients and dynamics of their adoption. It is important to know critical periods during vegetation, when the nutrients requirement is the greatest and when their deficiency causes the highest yield decrease. Needs of small grains for nitrogen, sulphur and potassium, in kg t^{-1} of grains and adequate quantity of straw are shown in the Tables 1 and 2 *(Malešević et al., 2008a)* and these plants requirements should be compensated by using organic and mineral fertilizers allowed in organic production.

According to presented data, the highest uptake/removal of nitrogen with grains has durum wheat and common spring wheat (Table 2). In the straw of oats and durum wheat, the nitrogen content is the highest, so the removal of this element is significant. At the same time, these cereals have the unfavorable grain to straw ratio. Harvest index is also very variable and it depends from environmental conditions. In favorable years harvest index is much better than in the unfavorable ones. Lodging of crops extremely lowers grain percentage in the total yield of small grains.

Table 2: Removal of nitrogen with grain and straw yield by various small grains (kg t^{-1})
Tabela 2: Iznošenje azota prinosom zrna i slame kod različitih vrsta strnih žita (kg t^{-1})

Small grain species *Vrsta žita*	Grain *Zrno*	Strow *Slama*	Totally *Ukupno*	Harvest index - *Žetveni index* (%)	
				Grain - *Zrno*	Strow - *Slama*
Wheat - *Pšenica*					
Winter - *ozima*	21	7	28	49	51
Spring - *jara*	25	7	32	50	50
Barley - *Ječam*					
Winter - *ozimi*	20	6	26	48	52
Spring - *jari*	18	8	26	46	54
Oat - *Ovas*					
Winter - *ozimi*	21	9	30	40	60
Spring - *jari*	22	12	34	38	62
Winter rye *–ozima raž*	22	6	28	42	58
Durim wheat - *Durum pš.*					
Winter - *ozima*	24	9	33	45	55
Spring - *jara*	26	11	37	42	58
Winter triticale – *oz. tritikale*	23	8	31	49	51

Dynamics of small grain nutrients uptake is in close correlation with the process of forming organic matter, i.e. growth and development of small grains. After the winter vegetation break, when temperatures become stable at about 5 °C, nutrients uptake continues with much greater intensity in comparison with autumn period. Tillering of winter crops lasts until the end of March and the beginning of April. Presence of sufficient quantities of easy-available forms of nutritive elements in the zone of root system is of crucial importance.

From the stage of stem elongation until the stages of flowering-pollination-beginning of kernel and milk development, cereals adopt remaining quantities of NPK nutrients, about 75%. From the beginning of kernel development until the complete maturity (45-50 days), most of small grains do not uptake new quantities of NPK, but translocate them from the older organs towards ear and grain, respectively. In about 45 days (in favorable years ~50), big quantities of dry matter are formed in grain. Due to high and intensive accumulation of organic matter in the period from pollination until complete maturity, of crucial importance for plants is that they are supplied with sufficient amounts of water and nutritive elements in soil solution, to have undamaged leaves and absence of weeds. Among abiotic factors, temperature is very important (daily about 25-26 °C, and nightly 11-12 °C) as well as direct sun radiation, without significant cloudiness. High temperature shortens the stages of kernel development and ripening.

Sowing. One of the most delicate technological measures in growing small grains is determining the optimal vegetative area for specific species and varieties of cereals. It depends from sowing time, tillering potential and weather conditions *(Malešević et al., 1994).* In organic production, time and sowing quality are especially important. Lower sowing rates should be used, and sowing time should be adjusted to specific agroecological conditions. Information in the Table 3 are valid for plain areas in Serbia and its surrounding.

Table 3: Time and rate of seeding of small grains in plain areas of Serbia
Tabela 3: Vreme i gustina setve strnih žita u ravničarskim krajevima Srbije

Small grain species *Vrsta žita*	Optimal seeding time *Optimalno vreme setve*	Average seeding rate *Orijentaciona gustina setve*	
		Grains/m^2	kg ha^{-1} of seed
Winter wheat – *oz. pšenica*	1. X - 25. X	450-500-600	180-200-260
Spring wheat – *jara pšenica*	1. II - 5. III	500-550-650	200-220-260
Winter barley – *oz. ječam*	20. IX - 5. X	250-300-400	140-160-180
Spring barley – *jari ječam*	5. II - 10. III	300-350-500	150-170-200
Winter oats – *oz. ovas*	20. IX - 10. X	350-400-450	100-120-160
Spring oats – *jari ovas*	1. II - 10. III	350-450-500	120-130-150
Winter triticale – *oz. tritikale*	20. IX - 10. X	400-450-500	170-180-230
Winter durum wheat – *oz. durum*	15. X - 1. XI	350-400-500	200-240-260
Spring durum wheat – *jari durum*	1. II - 5. III	400-450-550	200-250-270
Winter rye – *oz. raž*	15. IX - 5. X	350-400-500	160-180-220
Spelt wheat - *spelta*	25. IX - 10. X	350-500	160-240

Small grains demand special cultivation measures during the whole vegetative period, whose purpose is better development and protection of yield potential and quality. One of the most important measures is rolling after sowing, which enables quick and equal growing, and helps better root development. Rolling is also used at the end of winter, if the surface layer of the soil is soft. Harrowing is used on poorly structured soils, whose purpose is better aeration and provoke of tillering. Comb harrow can be used for the weeds suppression. These measures are especially significant for barley, oats, durum wheat and spelt. Bunt *(Tilletia sp.)* and Fusarium *(Fusarium sp.)* are the most important diseases as they are transferred by seed or occur as a consequence of frequent returning of grain at the same field. Late sowing and slow growth encourage the diseases development. Preventive measures listed in previous chapters are possible and efficient in suppressing diseases and pests.

The highest yield and the best quality of small grains are at the end of wax maturity, when grain moisture is between 20 and 26%. At this stage harvest losses are minimal, regardless of the fact if it is done in two or in one phase.

Alternative cereals suitable for growing in organic production

Many authors include *archaic wheat forms* in alternative crops. Archaic forms were grown in ancient times and have almost completely disappeared from modern production. These are Spelt (*Triticum spelta* L.), Einkorn (German name for one-grained wheat, also called small spelt - *Triticum monococcum* L.), Emmer (two-grained hulled wheat - *Triticum dicoccum* [Schrank] Schübl.) - as representatives of hulled wheats (they have tough glumes (husks) that tightly enclose the grains), and Kamut - Khorasan wheat *(T. turanicum* L.*; Triticum turgidum* L. *ssp. turanicum (Jakubz))* - archaic free-threshing wheat species. They all have significant advantages in relation to standard wheat forms, not only in nutritional aspect but in the productive and agro-economic aspects as well.

Alternative cereals can include and some species from standard production which are used a lot in the world, however, in Serbia they are not grown much or they are not grown at all. These cereals are important for nutritive and diet food completion with the status of *functional products (Demin and Žeželj, 2009).* Rye *(Secale cereale),* Triticale *(Triticosecale),* Grain sorghum *(Sorghum bicolor* L. Moench*),* various Millets and similar species belong to this group. Special group of alternative crops comprises of grain species that are not botanically included in cereals, but are lately used in different ways as raw materials in baking industry or production of special organic products. Buckwheat *(Fagopyrum esculentum* Moench*)* and Grain amaranth *(Amaranthus sp.)* can be included in this group.

Spelt (*Triticum spelta* L.) – (Serb. *spelta, krupnik, pir, pira*; Engl. *spelt*, *German wheat, large spelt*, Germ. *Dinkel*)

Production of spelt in the world is constantly increasing, so its products (baking products and pastas) can be found in Serbian markets and healthy food stores. It has minor needs for fertilization, and thus it is very popular in the world in organic production systems. Spelt belongs to the group of hulled wheat types. In its spikelets there are usually two grains, which must be extracted by peeling. Share of the grain in the spikelet of spelt is about 75%, while the rest are glumes (husks). Mass of 1000 grains is about 25-30g.

Chemical content and diet features of spelt: spelt grain has much more proteins (15-18%) compared to common wheat, which is closer to oats from the point of nutritive values. Furthermore, spelt has higher content of vitamins and some microelements (selenium) so its products have and antioxidant effects. Of particular importance is its higher fiber content, which makes it suitable for weight-loss diet or in various other diets for people exposed to stress and intellectual effort. Spelt has various uses: it is cooked, which is the simplest way to use it, and it is usually combined with vegetables. Spelt flakes are a common food for breakfast or as a component of musli. Very good food and dietetic properties has a spelt seedling, which can be used in a raw state or in the form of flakes, which is much more convenient for storage and preparation. Spelt bread with no additives is visually bad (not growing), but the nutritionally is very useful because it is much better digested than common wheat bread. White bread of spelt longer stays soft and flexible compared to common wheat bread, and bread from integral flour (of whole grain) stays fresh longer (up to one week), and has a pleasant, sweet taste. From spelt flour can make the dough without adding eggs, so this bread can eat and people sensitive to albumin. Also, people allergic to glutenin from other cereal can use spelt bread - it does not cause allergic reactions.

Spelt has a modest demand on the climatic and soil factors and agrotechnics, is tolerant to pests and diseases, and is very suitable for organic production. Its cultivation does not differ significantly from conventional wheat breeding.

Kamut *(Triticum turanicum* L.*; Tritucum turgidum ssp. turanicum*) - also called *Khorasan wheat*, and some taxonomists suggest the names *T. turgidum ssp. polonicum* and Egyptian durum wheat *(T. turgidum ssp. durum*), because of this type of wheat originate from Egypt to the Tigris-Euphrates valley. In many countries in the world this wheat species gained its place in the production and use as one of the most perspective cereal. Kamut has a large, high-quality grain with high gluten level in protein content. The grains are used for all products like common wheat, due to the similar kernel characteristics to durum wheats. Kamut is a free-threshing type of wheat, with big grains, glassy grain structure, with specific, often branched ear. Absolute grain mass is about 60 g. Grain usually contains about 30% more protein than common wheat, and has better mineral and amino acid balance. Also, it is characterized by a much better nutritional value and dietary properties. Products of kamut can consume people allergic to gluten, too.

In the Mediterranean regions it is grown as winter form. Although it is low yielded (1-2 t ha^{-1}), the kamut grain's ability to produce high quality without artificial fertilizers and pesticides makes it an excellent crop for organic farming. Technology of kamut growing does not differ significantly from common wheat growing.

Rye (*Secale cereale* L.): The increasing demand for rye bread, as the specialty of bakery products, has made producers to return again to the production of rye as alternative crop to wheat. The reasons for that are its specific taste and aroma of its products. In addition to the specific tastes, rye bread is attributed to certain medicinal value - it has been found reduced of diseases and mortality of cancer in the countries with stronger participation of rye bread in the diet. An important agronomic characteristic of rye are its thickness and rapid growth, and is a great precrop in crop rotation, as effectively suppress weeds.

Triticale (*x Triticosecale* Wittm. & Camus; syn. *x T. rimpaui* Wittm., x *Triticale* Müntzing) is an artificial cereal species created from a cross between wheat and rye. Favorable nutritional features and very high yields have made triticale one of the most perspective cereals, not only in human diet but in the feed production as well.

One of the many agronomic advantages of triticale is its high grain yielding, which with the application of appropriate agricultural technology, in our country can reach up the level of 7 to 8,5 t ha^{-1} *(Panković and Malešević, 2006).* Triticale is much more resistant to diseases in relation to wheat, and in this aspect is not behind the rye. It was also found that well-tolerated adverse agro-climatic conditions, especially to low temperatures. Triticale is appropriate for production in areas that are less favorable for wheat production; it is a highly promising cereal in hilly regions where wheat and barley production presents a certain risk *(Bavec, 2000).* It can also successfully replace extensive rye cultivars.

Grain sorghum (*Sorghum bicolor* (L.) Moench): Grain of modern, low-tanine sorghum hybrids today is almost the same in quality as the corn grain. It is edible, and in many countries around the world used for human consumption. Sown areas of grain sorghum in our country continue to rise, and domestic F1 hybrids Alba and Gold proved to be very well adapted, high yielding and favorable grain quality *(Berenji et al., 2008).* Quality tests have shown that the grain of grain sorghum can successfully replace corn in the diet of different categories of domestic animals.

The plant is native to tropical regions, adapted to temperate climate conditions. Due to the C4-type of photosynthesis sorghum is characterized by high potential of biomass production. Sorghum is a thermophilic species. It can endure tropical heats during the middle of vegetation better than corn. In conditions of limited soil and air humidity sorghum is capable of bigger biomass production than other crops. The most important factor of its drought tolerance is its powerful developed root system. Very effectively adopts the nutrients from the soil, and uses them more efficiently than corn.

As a precrop, sorghum dries soils a lot and intensively adopts nutrients from soil, especially nitrogen. Thanks to the effective adoption and the modest demands of plant towards nutrients, sorghum is satisfied with more rational fertilization.

Optimal time for regular seeding is in the second decade of April. Grain sorghum is sown on 50-70 cm x 7-8 cm in a row; and the planting depth should be at 3-4 cm. Rolling dry soil after planting encourages germination. Slow initial growth and development takes about a month after sowing. Care of crops consists of inter-row cultivation and hoeing, if necessary.

Millets - the *Panicum* genus includes more than 400 species, but only two are important in production: proso millet (*Panicum miliaceum* L.), and foxtail millet (*Panicum italicum* L., syn.: *Setaria italica ssp. maxima* Alef.)

Proso millet (common millet, broom-corn millet, Russian millet, Indian millet), was already being used as food in the early Stone Age. Its primary genetic centre is thought to be Middle and East Asia. Today, proso millet is produced in the U.S., South America, Australia, Japan, and some European countries (including Greece, Hungary). In Slovenia, during the years l986 to 1990, an average of 240 hectares were sown and the average grain yield was 1850 kg ha^{-1} *(Bavec, 2000a).*

It is the plant of warmer, south areas, which grows well in drier regions, too. Its distribution nearly matches with the zone of corn growing, but due to the short vegetation its growing area is wider than the one of corn. It has a relatively high yield potential. Average grain yield of this plant in our conditions is 2-3 t ha^{-1}. In a stubble-crop production, the yield is about 30% lower. *'Biserka'* (white) and '*Rumenka*' (red grain color) are the first two domestic types of proso millet. Both are characterized by short vegetation (which makes them convenient for stubble-crop production), also they have short stem (tolerance factor on lodging), and they are stand out by high yielding *(Berenji et al., 2008).*

For the development of common millet best temperature condition are between 18 and 24 ºC. Seeding is done when soil reaches the temperature 12-15 ºC. Low temperatures adversely affect growth at all stages of millet, especially during flowering and ripening. Millet has smaller demands towards humidity in comparison to other cereals. Hairiness of leaves and deep root system enables it to withstand stronger drought.

Millet can be cultivated in a monoculture, but in the system of organic crop farming it should be avoided. The best precrops for it are grain and forage legumes and fertilized intertilled crops. Pre-seeding preparation demands special attention because of its quite small seeds. Because of unequal seed maturation, two-phase harvest gives the best results; when the seeds from the middle part of the tassel are at the beginning of wax maturity.

Foxtail, foxtail millet *(Panicum italicum* L., *Setaria italica (L.) Beauv.) (Serb.* italijansko proso, bar proso)*:* Peeled foxtail grains gives highly rated, tasteful and nutritious groats, which can be cooked easily and quickly. In animal nutrition is used grain and aboveground mass, in the green state or as hay. Whole or milled seed is excellent food for poultry, too.

The length of vegetation period of the earlier foxtail varieties is 100-110 days and at the later ones 120-130 days, so in various organic farming systems it's suitable for stubble-crop growing. According to biological characteristics it is similar to common millet. It has slow initial growth and development. Until tillering it grows slowly, so because of that it requires soil cleaned of weeds. Foxtail is tolerant to drought and high temperatures, and has smaller demands towards soil than the common millet.

Buckwheat *(Fagopyrum esculentum* Moench*)* (Serb. *heljda, ajda, eljda, jeljda;* Germ. *buchweizen, heidenkorn):* used to grow primarily in Asia (Pendzab, Tibet and Poamur regions); today, however, wild plants can be found in China (Himalaya Mountains), Siberia, and the Far East. Buckwheat is grown for its fruits (achene), which when peeled are used in human nutrition. Kernel is characterized with high nutritive value; it is easily digested and very tasteful. Grain of buckwheat consists of kernel and outer hull (shell) that is 25-35% of grain mass. The useful part is the kernel (65-75% grain mass) that comprises of endosperm and germ. It is very rich in proteins, fat and vitamins, which makes grain very nutritious. By milling grains very respected buckwheat flour is gained, whose most important ingredients are proteins (11-15%), carbohydrates (starch; about 70%), fat (2-3%), raw fiber (10-20%) and mineral matter (1.5-2.5%). Due to the lack of gluten, buckwheat is especially interesting as diet food for the ill and older persons, and in the diet of children. Special interest for buckwheat was shown by nutritionists and dieticians as it does not contain gluten and has increased content of lysine and soluble proteins. Buckwheat is one of the main late bees grazing and it is the plant that has high honey potential (it can give up to 200 kg/ha of honey, dark colored). Finally, with numerous usages of buckwheat, in recent times especially emphasize and its medicinal properties *(Jiang et al., 1995).*

Agronomic importance of buckwheat lies in the fact that it grows fast and suppresses weed plants. It adopts phosphorus from hardly available compounds. Thus, it is an excellent precrop (especially as green manure) to other crops. Its main agricultural value is its short vegetation, so it can give yield in such geographical places and altitude where other plants would fail. Very short vegetative period enables buckwheat to be grown as stubble crop which enables two harvests in the year. Traditional way of growing buckwheat in Slovenia is stubble-crop production, but grown as a full-season crop it yields more *(Bavec et al., 2002).*

Cold and wet climate is the most suitable for buckwheat, which is typical for hills and mountains, but it has equal yield in plains, too. Minimal temperature for germination of buckwheat is 4 °C. It is very sensitive to frosts and it is damaged at -2 °C.

Buckwheat has no special demands when it comes to precrops, although it reacts well on growing after annual legumes, root plants and winter small grains. Monoculture is not recommended in intensive production. Buckwheat responds very good on fertilizers from the previous crop and it uses them efficiently, and reacts especially well on the manure. Sowing of buckwheat starts when the soil warms up at about 15 °C till depth of 10 cm. It can be sowed as main crop or stubble-crop, in narrow or in wide rows. Assortment of buckwheat varieties was earlier based on old Russian varieties, while today in our country there are registered varieties of buckwheat as well as some local varieties. After seeding in dry soil if necessary rolling is conducted. If weed and crust occur before germination, harrowing with light harrows is recommended. After germination of buckwheat, if planted in wide rows, cultivation between rows should be done. Depending of the of weeds population density and soil compaction, 1-2 cultivations are recommended till 10 cm depth, together with manual weeding in the rows. Crops in dense rows are weeded manually. Specific measure of buckwheat care, that can increase yield up to 500 kg/ha is pollination with the help of bees by bringing hives close to the field. Due to the long period of flowering and forming fruits, buckwheat matures unequally, so it is necessary to carefully determine harvest time. It is the best to do the harvest when about 2/3 of fruit are matured.

Grain yields are variable. In unsuitable soil or in conditions without pollination by insects, the yield may be as low as 500 kg ha^{-1}. The approximate yield for buckwheat is between 800 and 1000 kg grain ha^{-1}, but in favorable conditions, it can reach 2200 kg grain yield ha^{-1} *(Bavec, 2000b). Bavec et al., (2002)* suggest that the best-yielding buckwheat genotypes should be determined and introduced separately for stubble-crop or full-season production systems. Buckwheat grown as a full-season crop has a higher leaf area index, more clusters, better developed seeds, and 42% higher yield than the stubble-crop buckwheat *(Bavec et al., 2006).*

CONCLUSION

Cereals are inevitable plant species in organic production. Numerous species, subspecies, forms, types and varieties make their growing possible in the whole world and in almost all agricultural areas. In Serbia, there are valuable genetic collections of cereals which enable breeding of new genotypes intended for organic production, but they also give opportunity to revitalize old, authentic varieties.

Number of organic producers and areas under certified organic production in Serbia, especially in Vojvodina, are constantly increasing due to the growing market demands for healthy and safe food. Because of the rising demands and impossibility of production due to significant soil and air pollution, as well as violated relations in nature i.e. unexistence of basic agroecological preconditions for organic production, in developed countries there is a great lack of organic products in the market. That is why less developed countries, in which agro-ecosystem is undisturbed, have chance to increase their export through organic products.

Regarding the potentials we have, development of organic agriculture could give one new quality in life of local communities and our country as a whole. Development of organic agriculture should contribute to the optimal use of natural resources, increase of local production and overall improvement of status of inhabitants in rural regions.

The future of organic agricultural production in Serbia is still uncertain. There are conditions for its further development. Also, methods and technologies of organic production are known and available in many books, and even more on the many internet pages. However, it is necessary to interest potential producers by continual education and greater state encouragements and in that way provide grater penetration into world of ’organic’ trends.

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ORGANSKA PROIZVODNJA ŽITARICA - PRILIKA ZA POLJOPRIVREDU SRBIJE

MIROSLAV MALEŠEVIĆ, JANOŠ BERENJI, FRANC BAVEC, GORAN JAĆIMOVIĆ, DRAGANA LATKOVIĆ, VLADIMIR AĆIN

Izvod

Površine pod sertifikovanom organskom proizvodnjom u Svetu se konstantno povećavaju. Od njivskih kultura, u organskoj proizvodnji najzastupljenije su žitarice i krmno bilje, a od višegodišnjih zasada masline, voće i vinova loza. Stalni porast ljudske populacije nameće konstantnu potrebu za povećanjem proizvodnje žita, dok istovremeno specifični zahtevi tržišta u ishrani nameću potrebu da se pored konvencionalnih koriste i alternativna žita. Organska proizvodnja u Srbiji novijeg je datuma u odnosu na zemlje EU, a intenzivirana je uglavnom u proizvodnji povrća. Obzirom da su žita najzastupljenije vrste u organskoj proizvodnji u Svetu, cilj nam je da iznesemo osnovne postavke i mogućnosti njihovog gajenja u ovim sistemima i u našoj zemlji. Poseban akcenat dat je na specifičnostima «alternativnih» vrsta; kao što su durum pšenica, spelta, kamut, tritikale, razne vrste prosa, sirak za zrno i heljda.

Ključne reči: organska proizvodnja, žita, alternativna žita

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